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# MODEL FOR PREDICTION OF RETINAL BURNS (U)

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Headquarters
DEFENSE ATOMIC SUPPORT AGENCY
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by
JOHN L. WRAY
1st LIEUTENANT, USAF

TECHNICAL STAFF STUDY

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# MODEL FOR PREDICTION OF RETINAL BURNS

by

John L. Wray
1st Lieutenant, USAF

SPECIAL PROJECTS BRANCH
TEST PLANS AND PROGRAMS DIVISION
DEPUTY CHIEF OF STAFF, WEAPONS EFFECTS AND TESTS

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1 February 1962

HEADQUARTERS, DEFENSE ATOMIC SUPPORT AGENCY
WASHINGTON 25, D.C.

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## ABSTRACT

A theory for a method of predicting chorioretinal burns from nuclear weapon explosions is presented. Description of a computer program in FORTRAN II for use on IBM 704, 709, or 7090 is given. The calculation results in spatial and time varying temperature profiles in the energy absorbing layers of the eye tissue. Applying tissue damage criteria to the results will allow analysis of estimates of danger and safe distances for viewing nuclear explosions.

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## THEORY ON RETINAL BURN PREDICTIONS

Making predictions on the occurrence of retinal burns in persons or animals from a nuclear detonation essentially resolves itself into three separate, distinct problems. The first is the production of the thermal energy from the fireball itself; second is transmitting this energy through the intervening medium of atmosphere to the eye; and third is transferring this energy through the eye and depositing it in the layers of the eye in which heat and an accompanying temperature rise are produced due to the absorption of this energy. After considering each of these three areas separately, they are put together into one model which integrates the particular variables of each area. This model attempts to calculate the temperature rise in the retinal layers for a given explosion-observer relationship.

### SECTION I THERMAL ENERGY PRODUCTION FROM THE FIREBALL

For the purposes of this study, it is assumed that the fireball radiates as a black body obeying Planck's law for the energy density of an isothermal black body (Ref. 23):

$$\psi_\lambda \, d\lambda = \frac{8\pi ch}{\lambda^5} \cdot \frac{1}{e^{(ch/\lambda k T_{fb})} - 1} \, d\lambda \ \text{ergs/cm}^3 \tag{1.1}$$

$$E = 1/4 cA\psi = \frac{cA}{4} \int_{\lambda_1}^{\lambda_2} \psi_\lambda \, d\lambda \qquad \text{cals/cm}^2\text{/sec} \tag{1.2}$$

where: $k = 1.380 \times 10^{-16}$ erg/°C (Boltzmann Constant)

$h = 6.625 \times 10^{-27}$ erg sec (Planck's Constant)

$\lambda$ = wavelength

$c = 3 \times 10^{10}$ cm/sec.

$T_{fb}$ = temperature of radiating body (in this case, the fireball)

$\Psi$ = energy density (ergs/cm$^3$)

E = total emissive power between $\lambda_1$ and $\lambda_2$ of $\Psi$ (cals/cm$^2$/sec)

$$A = \frac{10^{-7}}{4.2} \text{ cals/erg}$$

Equation 1.2 states the energy transfer across the surface maintained at temperature ($T_{fb}$). It is seen, therefore, that in order to estimate the energy flux across the fireball surface as the explosion progresses in time, it is necessary to estimate the temperature at which the fireball is radiating from the time of explosion of the nuclear materials of the bomb to the time in which most of the energy is disipated from the fireball. It should be recognized that the phenomena of fireball growth depends upon the type of atmosphere in which it is exploded: if the shot is exploded within the atmosphere the fireball behaves differently than an explosion in outer space. Table 1 gives the sets of values of temperatures, radii, and corresponding times after explosion for a typical 1 KT explosion in sea level air which have been used in this program. It is assumed that the intensity of the fireball (temperature) does not vary greatly with yield, and that the various phases (time development) of the fireball phenomena scale as the square root of the yield. Also given are the corresponding radii of the fireball for the given times. It is assumed that these radii scale with yield to the 0.4 power of the yield.

In the following paragraphs, reference should be made to Table 2 which lists the program of the model in Fortran II language and procedure.

These relationships were scaled from information in Chapters 2 and 7 of Reference 15. The range of time given therein is not for sufficently short or long enough times; therefore, straight line extrapolation on log-log plot has been used to find the higher temperatures at shorter times, and straight line extrapolation was also used up to two seconds, after which a negligible temperature and a constant radius are used to fill out the times (for computational purposes). Because two seconds is more than 60 $t_{max}$, there will be less than 10% of the thermal energy remaining in the fireball, and its radiation rate will be very slow compared to earlier times.

It is necessary to calculate the energy release as a function of wavelength as well as time (through the temperature variation) because the atmosphere is wavelength selective as to transmissivity, as is also the pre-retinal ocular media. In addition, recent research results (Reference 1) have shown the energy absorption in the retinal layers to be wavelength dependant, so the energy must be carried through the entire model as a function of wavelength before being absorbed. As a practical matter, the wavelength range is limited to the range between 3500 and 15,000 Ångstroms, because of the ultra-violet cut-off in the atmosphere and the infra-red limitation in the spectral absorption of the pre-retinal ocular media. A wavelength band width of 100 Å is used.

There is no doubt that the interpretation of the fireball irradiance in this manner is grossly simplified, but because of the level of knowledge in the other areas and because of limitations of certain data, it is not deemed necessary to apply more sophisticated techniques until more complete information is assembled on tissue burn criteria, etc. However, modifications of the temperatures and radii used to better reflect actual situations would be well worthwhile in the prediction process when such information becomes available.

In the computation of the energy emission, the prediction program does it on a spectral basis for each of 115 wave bands of 100 Å width, beginning at 3500 Å.

$$I_\lambda = \frac{c T_\lambda E_\lambda}{(N_f)^2}$$

where: $I_\lambda$ is irradiance on retina, uncorrected for pre-retinal ocular media scattering and absorption (cal/cm$^2$/sec/cm) (FLL(I,J) in program).

c is appropriate units conversion factor.

$T_\lambda$ is atmospheric transmission value.

$E_\lambda$ = fireball emissive power (cal/cm$^2$/sec/cm)

$N_f$ = "f-number" of eye.

This information (the $I_\lambda$ or FLL (K) values) together with the fireball radius, is stored on tape, after applying atmospheric corrections, for the particular time period under consideration. It should be noted that the program utilizing Sense Switch # 3, (Table 2), will allow energies to be read directly into the relaxation program, so that the method outlined above for computing energy is not a pre-requisite to using the program

to compute the tissue temperature rise. In order to know the energy per unit area falling on the lens of the eye and within the image on the retina (uncorrected for ocular scattering and absorption) the values of SUMD and SUM are calculated. These values represent the total energy per unit area delivered to 1) the most center point of the image and 2) upon the lens surface, respectively.

SECTION II: ATMOSPHERIC TRANSMISSION

The amount of attenuation of radiant energy emitted from the fireball by the atmosphere depends upon the energy distribution (as a function of wavelength), the atmospheric composition, and the distance the observer is from the source. For the retinal burn problem, any energy which is either scattered or absorbed does not contribute to production of a temperature rise in the image area or the retina, unless the scattered radiation is multiply scattered in such a manner as to appear optically to originate in the fireball. Such multiple scattering is neglected in this model.

Degredation of the energy is mainly due to scattering of the dry air and scattering and absorption of the water vapor in the air. Quantitatively, the amount of scattering is dependant upon the number of scattering molecules (air density) while the amount of water vapor determines the scattering and absorption (temperature and relative humidity). Therefore, an atmosphere must be chosen and the density, temperature, and relative humidity specified quantitatively. The absorption coefficients of a standard atmosphere for each wavelength band must be corrected for the atmosphere chosen, then the total transmission coefficient for each wave band determined over the entire distance of the

path between fireball and the receiving eye (References 17 and 18).

In the part of the prediction model dealing with this calculation, two methods for calculating this transmissivity are used, both of which are based on a "flat earth" model. At large distances, a "flat earth" model will overestimate the transmission. Calculations of TRAN (L) or TRAN (M) (Table 3) depends upon whether there is an altitude difference between the source and receiver. If an altitude difference does exist, TRAN (L) is used: if there is not, TRAN (M) is calculated. The basic difference is that TRAN (L) allows for a variation in atmospheric density in the choice of constants and in the method of calculation (based on concept of "reduced height" atmosphere). These transmission coefficients are calculated for each of the 115 wavelength bands of 100 Å width and stored in memory to be used to calculate the energy emission spectrum (FLL(K)), described in Section I.

In dealing with the calculation of the atmospheric transmission, the situation that develops may be described as being "extremely precise and highly inaccurate". An intricate calculation method [illegible] been developed and is presented for use. However, because of the limited accuracy of the input data and because of the fallacy of trying to estimate temperature, relative humidity, and atmospheric composition under an average situation, the power of the method is limited to the accuracy of the known and specified conditions. Indeed, here is one area where a general method cannot overcome lack of specific data and facts.

The following paragraphs will outline the method developed and data

will be given, such as it is, for a typical Pacific Ocean atmosphere on a typical winter day at a typical time. It should be stressed that lack of experience with the program precludes a knowledgeable evaluation of the effect of various changes in the atmospheric input, but it is felt that unless appreciable range of values for a specific location or situation exist, the atmospheric transmission may be regarded as a second order effect in view of the highly influencial uncertainties in the other areas, such as weapon radiation output and tissue temperature damage criteria.

**Method**

The method used to estimate the atmospheric transmission is that outlined on page 432 of Reference 18. The method is based on observations of the transmission of solar radiation through a cloudless atmosphere (assumed dust free):

$$a_\lambda = a_{a\lambda} (a_{w\lambda})^w$$

where: $a_\lambda$ is the spectral transmission coefficient for a vertical path (optical air mass unity, when $p=p_o$).

$a_{a\lambda}$ is the vertical transmission considering only the effect of scattering by pure dry air.

$a_{w\lambda}$ is the transmission considering only the effect of scattering by 1 cm of precipitable water vapor.

w is the amount of precipitable water in the path, measured in cm.

For this study the relationship was modified to account for any straight path:

$$a_{t\lambda} = (a_{a\lambda})^m (a_{w\lambda})^{wm}$$

where: $a_{t\lambda}$ is the total transmission factor for any chosen optical path.

$m$ is the number of air masses in the optical path.

$w \cdot m$ is the total precipitable water vapor in the chosen optical path.

Table 3 gives values of $a_{a\lambda}$ and $a_{w\lambda}$ (called PTRAN and QTRAN in the program) based on Reference 18, pages 431, f.f.

**The Smithsonian tables also recognize absorption by the water vapor in the air and present corrections for this based on a spectrally integrated transmission coefficient. This correction is not applied to this problem for the following reasons:**

**1. It is not given spectrally.**

**2. The largest effect of the water vapor absorption would be in the lower and upper wavelength regions of the spectrum considered in this study. Because these regions are highly affected by the atmospheric scattering and the pre-retinal ocular absorption and scattering, its <u>total effect</u> on the <u>total</u> energy transmitted would be almost negligible, when these other attenuations are considered and accounted.**

To account for both horizontal and slant paths, two relationships for $a_{t\lambda}$ are used:

<u>Horizontal path</u>

$$a_{t\lambda} = (a_{a\lambda})^{s} \, (a_{w\lambda})^{w \cdot m}$$

where: $s$ = horizontal distance in miles divided by 5.25 miles which is the distance through an amount of sea level atmosphere equivalent to a vertical path (optical air mass unity, when $p = p_o$).

This is written in the program as:

$$\mathrm{TRAN(M)} = \left[\mathrm{PTRAN(M)}\right]^{S} \left[\mathrm{QTRAN(M)}\right]^{(\mathrm{CON}\ 5}$$

Slant path

$$a_{t\lambda} = \left\{ \left[ 1.0 - (M_L - M_H)\,(1.0 - a_{a\lambda}) \right]^A \right\} (a_{w\lambda})^{CW_{mf}DH_r}$$

where: $M_L$ is the vertical air mass decimal percent above the lower altitude (of observer or explosion). See Table 4.

$M_H$ is the vertical air mass decimal percent above the higher altitude (of observer or explosion). See Table 4.

The above equation has been written in the program as:

$$TRAN(L) = (1.0 - CON\ 4(1.0 - PTRAN(L)))^A\ (QTRAN(L))^{CON\ 3}$$

where: $A = \left[ 1 + \left(\frac{D}{h}\right)^2 \right]^{1/2}$

D is the horizontal distance.

h is the vertical distance between explosion and observer.

$C \cdot W_{MF} \cdot H_r$ represents the average precipitable water vapor over the slant distance per horizontal mile of optical path (measured in centimeters of water).

$W_{MF}$ is the water vapor multiplication factor which accounts for the assumption that there is negligible water vapor above a level of 5 miles altitude above sea level and that the lower of the observer or explosion altitude may or may not be at sea level. For calculation of this factor, see Appendix A.

C is a constant which represents the centimeters of precipitable water vapor per horizontal mile of air at sea level. For Pacific atmosphere at 25° C and 100% relative humidity, an approximation for C at sea level is 3.48 cm. (See Table in Appendix A for

other values of C, as a function of altitude. If the type of atmosphere is changed, other values of C for the new location will be needed.)

$H_r$ is the relative humidity averaged with water content over the optical path.

D is the horizontal distance between observer and explosion.

## SECTION III: ENERGY TRANSMISSION AND ABSORPTION IN THE EYE, AND METHOD OF CALCULATING THE TEMPERATURE PRODUCED

(The calculation of a temperature rise in the retinal layers)

Research results (Reference 1) have yielded values which may be used as energy transmission values (as a function of wavelength) through the pre-retinal ocular media. These are presented as a function of the 115 wavelength bands of 100 Å each in Table 3. Table 5 presents the total absorption coefficients (in decimal percent) used for the layers of pigmented epithelium and the choroid, as a function of wave length for 100 Å bandwidths, starting at 3500 Å (Reference 1). These three factors are appropriately applied to determine the absorption in each of the two layers. (Refer to Figure 1: 1 denotes region of P.E., 2 denotes region of choroid, and 3 denotes the volume surrounding regions 1 and 2).

<u>Absorption in P.E. (Region 1) -- cals/cm$^3$/sec</u>

$$AI = \sum_{\lambda = 3,500\ \text{Å}}^{15,000\ \text{Å}} \frac{FLL\ (\lambda)}{RET}\ (1\text{-}ABSMO(\lambda))\ (ABSI(\lambda))\Delta\lambda \qquad (3.1)$$

where: RET is thickness of P.E. ($\approx 10\mu$).

$\Delta\lambda = 100$ Å.

Absorption in Choroid (Region 1) -- $cals/cm^3/sec$

$$AII = \sum_{\lambda = 3500\,\mathring{A}}^{15,000\,\mathring{A}} \frac{FLL\ (\lambda)}{RET} \ (1\text{-}ABSMO(\lambda))\ (1\text{-}ABSI(\lambda))\ (ABSII(\lambda))\ \Delta\lambda \tag{3.2}$$

where CHOR is the thickness of choroid (for humans ≈80μ to 100μ).

A correction factor of $\frac{R^2}{(3.5 \times 10^{-4})}$ is applied to AI and AII if the radius of the image (R in centimeters) is less that 3.5μ, which is considered to be an average image limitation value, based on chromatic abberation, diffraction, and corrected for a $\frac{1}{\lambda^4}$ energy distribution (Reference 19).

The resulting values of AI and AII are then used as heat sources in a heat conduction problem which attempts to calculate the spatial and time varying temperature profiles in the volume, including, and surrounding the volume defined by the fireball optical image on the retina and the layer thickness of the absorbing tissues.

Certain basis assumptions are made about the "heat generation" model. It is assumed that all tissue thermal properties are nearly the same as water and that absorption and conduction occur uniformly. No corrections are made for changes in tissue temperature. All heat that is not absorbed in the pigmented epithelium or choroid is discarded as not causing a significant contribution to the temperature rise in those two regions. There is assumed conduction in the tissue surrounding the absorbing volume, but no heat generation. The absorbing volumes "grow" in radius as the image radius expands with time as a result of fireball growth, but the thicknesses of absorbing properties do not vary with time or change with temperature. Re-radiation of energy due to the local temperature rise in the area of the absorbing volume is neglected. There is some indication (Reference 20) that the absorbing of the radiant

energy in the pigmented epithelium does not take place uniformly, but is absorbed in pigmented cells which are interspaced between semi-transparent tissue. This local absorption effect is neglected in the model, as quantitative information on this method of absorption is not available. However, the surface to volume ratio of these cells is considered to be so large that there should not be appreciable build-up in temperature within them before conduction will dissipate the heat to the surrounding tissues. Should the heat generation perform more as surface heating than volume heating in these cells, an entirely different method of treating the heat source would be required. However, this remains to be proven experimentally or otherwise demonstrated formally.

The fundamental heat conduction equation is (Reference 21):

$$\nabla^2 v_{(t)} + \frac{A_{(i)}}{k} = \frac{\rho \, c_p}{k} \frac{\partial v_{(t)}}{\partial t} \qquad (3.3)$$

where: $k$ = conductivity of material.

$\rho$ = density of material.

$c_p$ = specific heat of material.

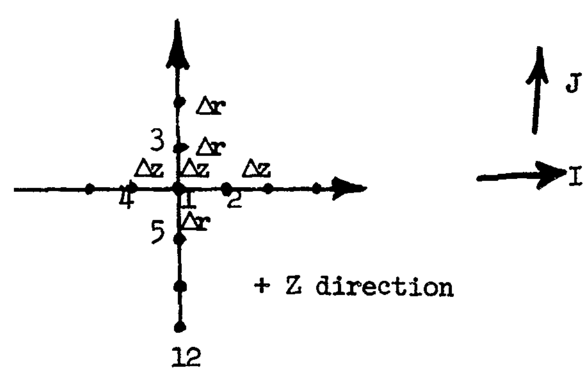
$\nabla^2$ = Laplacian operator.

$v_{(t)}$ = temperature as a function of time.

$t$ = time.

$A_{(i)}$ = volume absorption rate in region (i).

Equation 3.3 is put into difference equation form according to the following diagram:



Expressing the Laplacian operator in terms of a cylindrical difference equation for the temperature of point 1 in terms of points adjacent to points 3, 5, 6, and 9 yields:

$$\nabla^2 v = \frac{\partial^2 v}{\partial r^2} + \frac{1}{r}\frac{\partial v}{\partial r} + \frac{\partial^2 v}{\partial z^2} \qquad \text{for } \frac{\partial v}{\partial \Phi} = 0$$

$$\frac{\partial^2 v}{\partial r^2} \approx \frac{\dfrac{v_3 - v_1}{\Delta r} - \dfrac{v_1 - v_5}{\Delta r}}{\Delta r} = \frac{v_5 - 2v_1 + v_3}{\Delta r^2}$$

$$\frac{\partial^2 v}{\partial z^2} \approx \frac{\dfrac{v_2 - v_1}{\Delta z} - \dfrac{v_1 - v_4}{\Delta z}}{\Delta z} = \frac{v_4 - 2v_1 + v_2}{\Delta z^2}$$

$$\frac{\partial v}{\partial r} \approx \frac{v_3 - v_5}{2\Delta r}$$

$$\therefore \nabla^2 v \approx \frac{v_5 - 2v_1 + v_3}{\Delta r^2} + \frac{v_3 - v_5}{2r\Delta r} + \frac{v_4 - 2v_1 + v_2}{\Delta z^2} \tag{3.4}$$

$$P1 = \frac{A(1)}{k} = \frac{AI}{k} \text{ ( for region 1),} \tag{3.5}$$

$$P1 = \frac{A(2)}{k} = \frac{AII}{k} \text{ (for region 2),} \tag{3.5}$$

$$P1 = \frac{A(3)}{k} = 0 \text{ (for region 3)} \tag{3.5}$$

$$\frac{\partial v}{\partial t} \approx \frac{v_1 - v_{1(n-1)}}{t - t_{(n-1)}}, \tag{3.6}$$

where: subscript n-1 refers to the temperature at point 1 at the preceeding relaxation time.

Equation 3.4, 3.5, and 3.6 then are used to approximate Equation 3.3 in finite difference form:

$$\frac{v_5 - 2v_1 + v_3}{\Delta r^2} + \frac{v_3 - v_5}{2r\Delta r} + \frac{v_4 - 2v_1 + v_2}{\Delta z^2} + P1 = \left(\frac{\rho c_p}{k}\right) \frac{v_1 - v_{1(n-1)}}{t - t_{(n-1)}}$$

from which :

$$v_1 = \frac{\dfrac{v_5 + v_3}{\Delta r^2} + \dfrac{v_3 - v_5}{2r\Delta r} + \dfrac{v_4 + v_2}{\Delta z^2} + P1 + \dfrac{\rho c_p}{k}\,\dfrac{v_{1\,(n-1)}}{t - t_{(n-1)}}}{\left(\dfrac{\rho c_p}{k(t_1 - t_{(n-1)})} + \dfrac{2}{\Delta r^2} + \dfrac{2}{\Delta z^2}\right)} \qquad (3.7)$$

Initial and boundary conditions

At $t = 0$, all grid points $v(I,J) = 0$,

where: $1 \leq J \leq$ LAT, $1 \leq I \leq$ LONG, I and J integers, LAT and LONG defining the number of grid points in the radial and axial directions.

Equation 3.7, therefore, calculates the temperature rise above the ambient body temperature, which may be chosen to reflect the body temperature of subject being considered. (However, $v(I,J) = T$ where T is any value, by changing statement T = 0.0 following statement 11 of the program; calculated temperatures would then be actual temperatures if T were body temperature.)

Absorption function P1 is defined by equations (3.5).

At the boundaries between regions 1 and 2, 1 and 3, and 2 and 3,

$v_1 = v_2$, $v_1 = v_3$ and $v_2 = v_3$.

Also: $$\frac{\partial v_1}{\partial z} = \frac{\partial v_2}{\partial z}$$

$$\frac{\partial v_1}{\partial r} = \frac{\partial v_3}{\partial r}, \quad \frac{\partial v_1}{\partial z} = \frac{\partial v_3}{\partial z}$$ at the appropriate boundries.

$$\frac{\partial v_2}{\partial r} = \frac{\partial v_3}{\partial r}, \quad \frac{\partial v_2}{\partial z} = \frac{\partial v_3}{\partial z}$$

In region 3, the outer cylindrical boundary is assumed to be non-conductive so that:

$$\frac{\partial v_3}{\partial r} = \frac{\partial v_3}{\partial z} = 0$$

at outer grid points.

To effect this condition,

$$\left.\begin{aligned} v(1,J) &= v(2,J) \\ v(I,25) &= v(I,24) \\ v(49,J) &= v(48,J) \end{aligned}\right\}$$

(Numbers 24, 25, 48, 49 would depend upon grid size -- these are LAT - 1, LAT, LONG - 1, and LONG, respectively.)

is dictated by the program. The physical effect of this is that no heat is lost from region 3. As long as region 3 is kept large compared to regions 1 and 2, it is felt that no loss of heat from region 3 counter-balances neglecting absorption in region 3. Heat generation in the three regions is governed by equation 3.5 stated previously.

From the above, it is seen that the temperature of any point in a grid can be found if the heat source, the previous temperature of that point, and the surrounding four temperatures are known. A grid is set up in the retinal layers to represent a radial plane of a right circular cylinder.

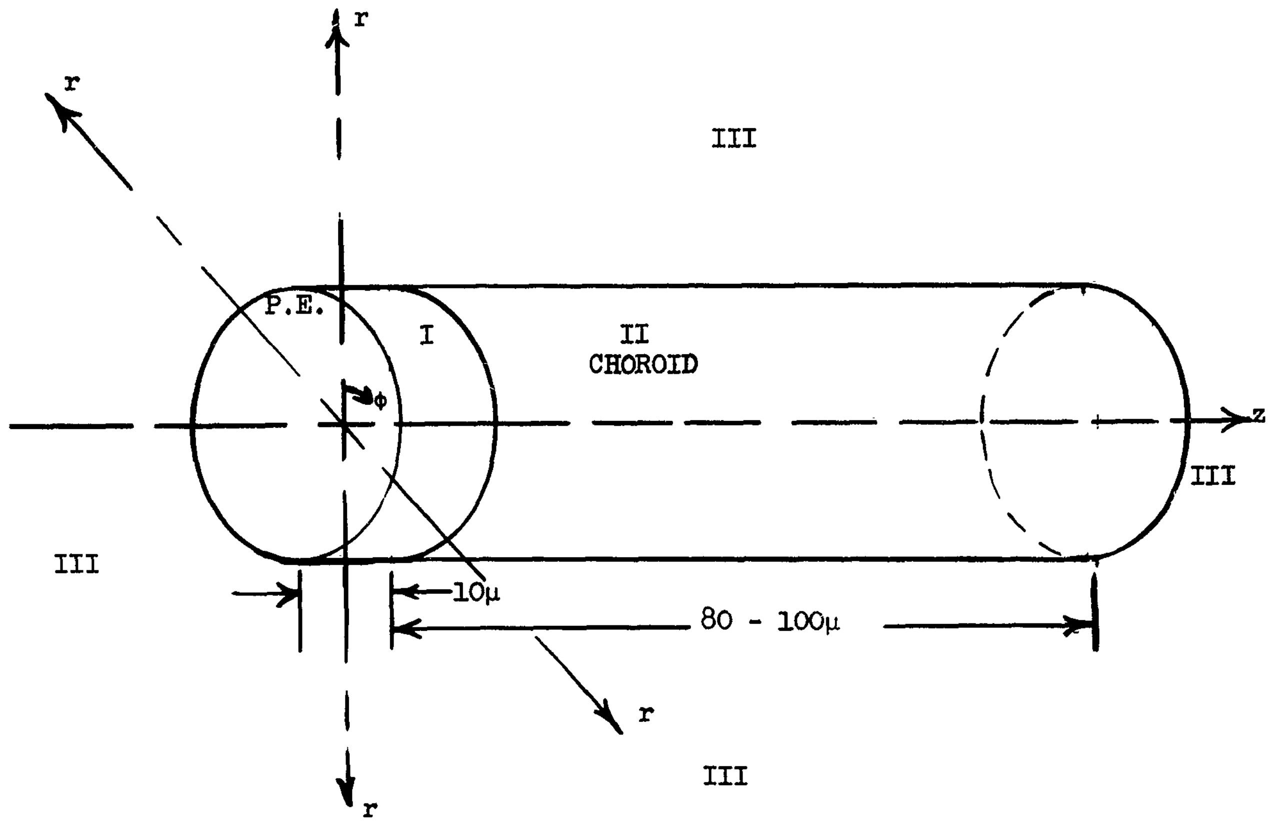



Figure 1. Schematic Diagram of Absorption and Conduction Volume

It is assumed that the energy absorption (and hence the temperatures) does not vary with angle $\phi$.

The resulting grid is as follows (numbers refer to sequence of applying equation (3.7)).

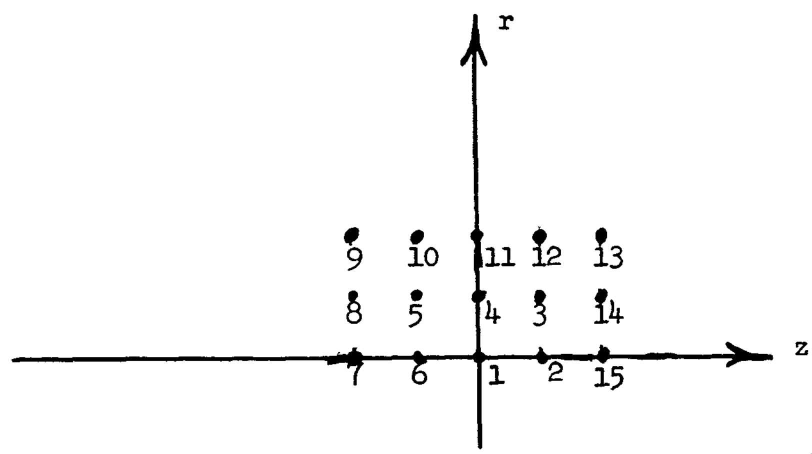



Figure 2. Relaxation Grid Numbered to Show Progression of Applying Equation (3.7).

Equation 3.7 is applied first at point 1, then at point 2, etc., in a hemispherical motion about a center of point 1. By progressing in this manner through the grid several times, the temperature of each grid point "relaxes" to values which approximate the temperatures for the time specified. A test is built into the program so that when the largest change in temperature of any point in the grid is less than a pre-assigned percentage of the largest temperature in the grid, the relaxation procedure is halted. The smaller this TEST percentage is made, the greater the accuracy of the results. Experimentation with this value is needed in most situations. The grid in Figure 2 is superimposed on Figure 1 so that the starting point (point 1) is the center of the pigmented epithelium layer, on the z axis. The size of the grid is chosen to be about 3 times the largest image radius and about three or four times as long as the thickness of the choroid.

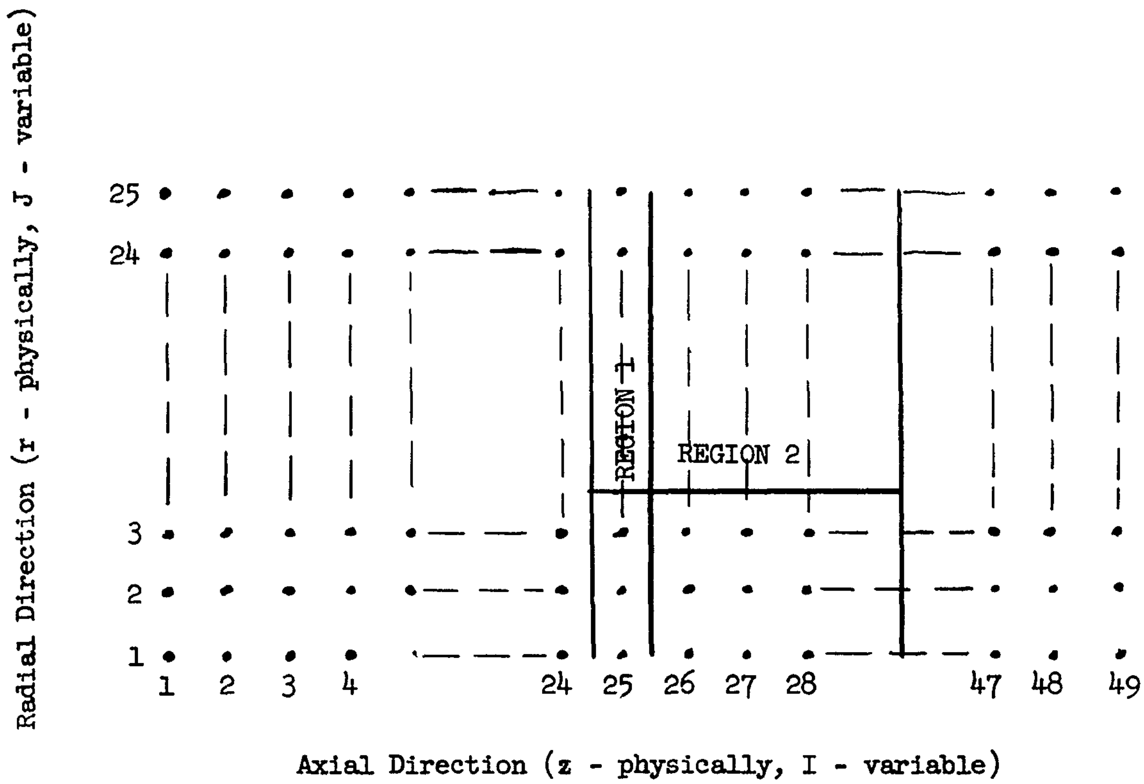
After a relaxation is completed for one time period, time is incremented and new $A_{(j)}$ values are calculated and the relaxation process commenced again. The program halts or goes to the next program when zeroes appear in FTIMS(I) and DELTI(I). (Therefore, FTIMS(9) and DELTI(9) must always be zero.)

Typical variable data input is listed in Table 6. Results of the calculations for the temperature profiles at various stages of the explosion development are listed in Table 6.

Grid size

The grid used presently for this program is 49 points in the z (axial) direction and 25 points in the r (radial) direction (a point is denoted by (I,J) variables as to point location, i.e., (25,1) denotes

center of pigmented epithelium on z axis, (4,13) denotes the 4th radial point from the center line which is in z column number 13.




The physical side of the grid depends upon the values for $\Delta r$ and $\Delta z$. These values are usually selected by estimating the largest image radius, multiplying this value by 3 to allow for conduction, and then dividing it by the number of radial space increments.

$$\Delta r = \frac{3r_i \text{ (largest)}}{24} = \frac{r_i \text{ (largest)}}{8}$$

It is generally convienient to let $\Delta z = \Delta r$, but the product of $\Delta z$ and the number of axial grid points must generally be at least 300 to 400

microns in order to allow proper conduction axially.

Provisions for other attenuators

A Constant Attenuation Factor (abbreviated CAF in the program) is provided so that attenuators such as plexiglass or fixed, constant density (with wavelength) filters may be accommodated. The proper transmission value of the attenuator (in decimal percent) is then stated in the input variable for CAF. If no such attenuator is present in the physical problem, a value of CAF = 1.0 is inserted as the value for CAF. (Actually, the words "constant attenuation factor" are a misnomer -- it should be "constant transmission factor" because of its method of use.)

Calculation of Henriques' Damage Integral

There is a provision in the program (c.f. statements 150 to 154) for calculating the integrated cellular damage based on the Henriques' Damage Integral emperical relationship. This calculation can be utilized by placing Sense Switch 4 in the down position. The calculation for $\Omega$ is made for various grid points which are determined by reading, as input, various values of LEX(I); a pair of LEX(I) values corresponding to a grid point in terms of (I,J). By changing the statement following statement 400 (Sigma(L) = etc.) any relationship for Henriques' function may be utilized. It is anticipated that this portion of the program may become increasingly valuable in applying damage criteria as the program is utilized in analyzing laboratory produced permanent damage where the damage producing temperature may be estimated by staining technique. Ultimately, however, the dependance will be directly related to the confidence in the Henriques' relationship used.

Damage criteria

In order for this model to be effective, some criteria must be established to determine when irreparable damage occurs. Previous attempts (References 22 and 16) have been to specify the damage thresholds in terms of irradiance ($cals/cm^2/sec$) radiant exposure ($cals/cm^2$), image size, and time of exposure. It is now thought that the temperature of the absorbing and conducting tissue of the retina is more fundamental to the damage mechanism that the total energy or energy rate of deposition. If this be true, the damage criteria should be related to the temperature-time history of the irradiated material. Research efforts (at the Medical College of Virginia) are now in progress to attempt to demonstrate this point. If this damage relationship can be found experimentally, it would provide damage criteria for the predictions produced by this program.

Until the laboratory results are available, an interim method to estimate the burn-damage criteria has been used to evaluate the results of calculations based on this model. It is reasoned that irreparable damage occurs where the tissue is heated above the temperature at which boiling of the fluids will occur ( $\sim 100^\circ$ C or a temperature rise of $\sim 65^\circ$ C). It is also thought that irreparable damage can occur when there is no evidence of boiling or vapor eruption in the tissue, which means a macroscopic maximum temperature somewhat below $100^\circ$ C was obtained. On the lower end of the scale, it is thought that irreparable damage is not likely if a temperature rise of less than $20^\circ$ C exists for a short time (less than a second).

Thus, it is reasoned that a temperature rise of greater than $20^\circ$ C, but less than $65^\circ$ C, for a time period of the order of the blink reflex

or less, will be the temperature range in which irreparable damage is produced. A more specific criteria awaits further research results.

Results

Input values and results and print-out for a typical computer run are included in Table 6.

Operation Notes

This program has been operated on IBM 704, 709, and 7090 computers with 32,000 word memory units. Running time for an average problem is approximately 20 - 30 minutes on the 704 and 5 - 10 minutes on the 7090. A calculation using one yield and five distances to determine a safe distance requires about 35 minutes. Of course these times are highly dependant on the grid size, time increments, and TEST values used. Use of Sense Switch # 2 allows consecutive runs to be made without stopping the computer; however, the same input data must be used, and only the variable cards can be changed from run to run in this procedure. Computer units with 8k memories may be used by utilizing a smaller number of grid points.

APPENDIX A

Calculation of $W_{mf}$ (WMFI)

Calculation of the precipitable water vapor multiplication factor may be demonstrated from the following:

TABLE A-1

Values of Precipitable Water Vapor for a Typical Pacific Atmosphere as Might be Found Near Hawaii in the Fall

| Altitude (mi) | Temp (°C) | Water Vapor Density | Relative Humidity | Cm of Precipitable Water Vapor per Horizontal Mile (100% Rel. Humidity) Constant C | Cm of Precipitable Water Vapor per Horizontal Mile at Indicated Relative Humidity |
|---|---|---|---|---|---|
| Altitude (mi) | Temp (°C) | Water Vapor Density | Relative Humidity | | |
| 0.0 | 25 | 0.02178 | 0.80 | 3.48 | 2.78 |
| 0.5 | 17 | 0.01447 | 0.85 | 2.32 | 1.98 |
| 1.0 | 13 | 0.01135 | 0.80 | 1.82 | 1.46 |
| 1.5 | 10 | 0.00941 | 0.55 | 1.51 | 0.83 |
| 2.0 | 7.5 | 0.00800 | 0.42 | 1.28 | 0.54 |
| 2.5 | 4 | 0.00636 | 0.42 | 1.00 | 0.42 |
| 3.0 | 0.0 | 0.00485 | 0.42 | 0.78 | 0.33 |
| 3.5 | - 6 | 0.00350 | 0.42 | 0.56 | 0.24 |
| 4.0 | -13 | 0.00250 | 0.42 | 0.40 | 0.17 |
| 4.5 | -23 | 0.00170 | 0.42 | 0.27 | 0.11 |
| 5.0 | -34 | 0.00120 | 0.42 | 0.19 | 0.08 |
| | | | | | 8.94 |

Average from 0 to 5 miles $= \frac{8.94 - 0.08}{10} = 0.886$ cm water/mile.

$$\therefore\ C \cdot W_{mf} \cdot H_r = 0.886 \tag{A.1}$$

$$W_{mf} = \frac{0.886}{C \cdot H_r} \tag{A.2}$$

for values of $C = 3.48$ and $H_r = 0.5$,

$$W_{mf} = \frac{0.886}{3.48 \times 0.8} = 0.32 \tag{A-3}$$

This is the value for $W_{mf}$ for a slant path between altitudes of 0 and 5 miles, and an average relative humidity of 80% in the first several thousand feet of atmosphere.

Should the higher altitude be above 5 miles, a correction factor must be applied to $W_{mf}$ to account for the fact that the entire horizontal distance (D) does not apply:

$$W_{mf} = \frac{0.886}{C \cdot H_r}\left(\frac{5}{h}\right) \tag{A.4}$$

If the lower altitude is above sea level, the proportion of the last column in Table A-1 should be omitted in computing the average precipitable water vapor. For example, should the lower altitude be 3000' and the higher altitude 5 miles, the average precipitable water vapor would be $\frac{8.86 - 2.78}{9} = 0.67$ cm water/mile. Therefore, equation A.1 should now be:

$$C \cdot W_{mf} \cdot H_r = 0.67 \tag{A.5}$$

TABLE 1

Normalized time vs. fireball temperature and radius. (XNORT x $10^{8}$ seconds -- TEMP1 x $10^{-3}$ degrees C -- RADII x 10 feet).

| | | | | | | |
|---|---|---|---|---|---|---|
| 00000010 | 00000020 | 00000030 | 00000040 | 00000050 | 00000060 | 00000070 |
| 20000 | 10000 | 9000 | 8200 | 7600 | 7000 | 6600 |
| 12 | 15 | 16 | 19 | 22 | 24 | 26 |
| 00000080 | 00000090 | 00000100 | 00000200 | 00000300 | 00000400 | 00000500 |
| 6400 | 5800 | 5600 | 3700 | 2800 | 2000 | 1700 |
| 27 | 29 | 30 | 42 | 49 | 59 | 65 |
| 00000600 | 00000700 | 00000800 | 00000900 | 00001000 | 00002000 | 00003000 |
| 1300 | 1100 | 920 | 800 | 740 | 340 | 210 |
| 69 | 75 | 80 | 87 | 89 | 120 | 140 |
| 00004000 | 00005000 | 00006000 | 00007000 | 00008000 | 00009000 | 00010000 |
| 150 | 120 | 92 | 80 | 62 | 60 | 54 |
| 170 | 190 | 200 | 220 | 240 | 250 | 260 |
| 00020000 | 00030000 | 00040000 | 00050000 | 00060000 | 00070000 | 00080000 |
| 23 | 15 | 11 | 9.0 | 7.4 | 6.4 | 5.5 |
| 300 | 430 | 480 | 530 | 560 | 580 | 620 |
| 00090000 | 00100000 | 00200000 | 00300000 | 00400000 | 00500000 | 00600000 |
| 4.8 | 4.4 | 2.2 | 1.8 | 1.9 | 2.2 | 2.5 |
| 660 | 680 | 880 | 990 | 1080 | 1140 | 1210 |
| 00700000 | 00800000 | 00900000 | 01000000 | 02000000 | 03000000 | 04000000 |
| 2.7 | 3.2 | 3.5 | 3.8 | 6.6 | 8.0 | 8.5 |
| 1260 | 1320 | 1350 | 1360 | 1680 | 1860 | 1960 |
| 05000000 | 06000000 | 07000000 | 08000000 | 09000000 | 10000000 | 20000000 |
| 8.5 | 8.2 | 7.8 | 7.0 | 6.4 | 5.9 | 3.4 |
| 1990 | 2040 | 2080 | 2100 | 2160 | 2190 | 2280 |
| 30000000 | 40000000 | 50000000 | 60000000 | 70000000 | 80000000 | 90000000 |
| 2.6 | 2.1 | 1.8 | 1.5 | 1.4 | 1.3 | 1.2 |
| 2340 | 2370 | 2410 | 2410 | 2410 | 2410 | 2410 |
| 100000000 | 200000000 | 300000000 | 400000000 | 500000000 | 600000000 | 700000000 |
| 1.1 | 0.7 | 0.7 | 0.7 | 0.7 | 0.7 | 0.7 |
| 2440 | 2470 | 2470 | 2470 | 2470 | 2470 | 2470 |
| 800000000 | 900000000 | 1000000000 | 1100000000 | 1200000000 | 1300000000 | 1400000000 |
| 0.7 | 0.7 | 0.7 | 0.7 | 0.7 | 0.7 | 0.7 |
| 2470 | 2470 | 2470 | 2470 | 2470 | 2470 | 2470 |
| 1500000000 | 1600000000 | 1700000000 | 1800000000 | 1900000000 | 2000000000 | 3000000000 |
| 0.7 | 0.7 | 0.7 | 0.7 | 0.7 | 0.7 | 0.7 |
| 2470 | 2470 | 2470 | 2470 | 2470 | 2470 | 2470 |
| 4000000000 | 5000000000 | 6000000000 | | | | |
| 0.7 | 0.7 | 0.7 | | | | |
| 2470 | 2470 | 2470 | | | | |

TABLE 2

```
*       PAUSE
*MAIN PROGRAM
*       CARDS ROW
*       LIBE
*       LIST8
```

```
      EYE PROBLEM PROGRAMED BY LAWTON BLACKBURN JR.
      DIMENSION RUNNO(3),CLASSE(3)
      DIMENSION RADI( 500),TEMP(500),BLK(49,25),BLK1(49,25),PTRAN(116),
     1FLL(116),QTRAN(116),XNORTI(90),TEMP1(90),RADII(90),ABSMO(116),ABSI
     2(116),ABSII(116),DELTI(9),FTIMS(9),LEX(22),OMEGA(10),SIGMA(10),TRA
     3N(116)
      IPAGE = 1
      READ 174,(PTRAN(I),I=1,116)
      READ 174,(QTRAN(I),I=1,116)
      READ 176,(XNORTI(I),I=1,88)
      READ 178,(TEMP1(I),I=1,88)
      READ 180,(RADII(I),I=1,88)
      READ 182,(ABSMO(I),I=1,116)
      READ 182,(ABSI(I),I=1,116)
      READ 182,(ABSII(I),I=1,116)
    9 READ 390,((RUNNO(I),I=1,3),(CLASSE(I),I=1,3))
      READ 186,RET,CHOR,TEST,DELZ,DELR,NO1,IM,IN,KK,LONG,LAT
   10 READ 188,YIELD,ALT,DIST,FNUMB,ANGLE,FOCAL,AMUL,AMFL,AMFH,RELHU,CAF
     1,WMFI
      READ187,CON,CON2
      IF(SENSE SWITCH 4)14,11
   14 READ 175,(LEX(I),I=1,20)
      DO 15 L = 1,10
   15 OMEGA(L) = 0.0
   11 READ 189,(DELTI(I),I=1,9)
      READ189,(FTIMS(I),I=1,9)
      SENSE LIGHT 1
      X=0.0
      T=0.0
      LEX(21) = 0
      LEX(22) = 0
      KO=1
      GO TO 413
   12 FTIME = FTIMS(KO)
      DELT = DELTI(KO)
      NIDT=FTIME/DELT
   13 TMAX=(.032*YIELD**.5)
      IF(YIELD-10.)16,17,17
   16 TMAX=TMAX*1.3
   17 J=1
      DO 25 K=1,NIDT
      X=X+DELT
      Y=X/TMAX
   22 IF(Y-XNORTI(J))24,24,23
   23 J=J+1
      GO TO 22
   24 TEMP(K)=TEMP1(J)
   25 RADI(K)=RADII(J)*YIELD**.4
      DWAVE=1.0E-6
      CON3=CON*WMFI*DIST*RELHU
      CON4=AMFL-AMFH
      CON5=CON2*DIST*RELHU
      IF(SENSE SWITCH 3)213,27
   27 IF(ALT)208,32,28
   28 A=(1.+(DIST/ALT)**2)**.5
      DO 30 L=1,116
```

EYE PROBLEM PROGRAMED BY LAWTON BLACKBURN JR.

```
30 TRAN(L)=((1.0-CON4*(1.0-PTRAN(L)))**A)*(QTRAN(L)**CON3)
   GO TO 35
32 S=DIST*AMFL/5.25
   DO 34 M=1,116
34 TRAN(M)=(PTRAN(M)**S)*(QTRAN(M)**CON5)
35 REWIND 8
   Y1=COSF(ANGLE)
   Z1=.224E-12
   X1=1.44 E-3
40 DO 47 N=1,NIDT
41 BC=35.E-6
   DO 46 JI=1,116
   FL=Z1*TRAN(JI)/(BC**5*(2.71828**(X1/(BC*TEMP(N)))-1.))
   FLL(JI)=FL*Y1/FNUMB**2
   BC=BC+DWAVE
46 SUM=SUM+FLL(JI)*DWAVE*DELT
   SUMD=SUM*FNUMB**2*RADI(N)**2/(5280.0**2)/(ALT**2+DIST**2)
47 WRITE OUTPUT TAPE 8,190,(FLL(K),K=1,116)
   IF(KO-1)411,410,411
410 PRINT 301,(RUNNO(I),I=1,3)
   PRINT 302
411 PRINT 303,SUM,SUMD,FTIME
202 LATA = LAT-1
203 LONGA = LONG-1
213 MID=(LONG+1)/2
214 TS=MID
50 N1=(RET/2.)/DELZ+TS
   N2=(RET/2.+CHOR)/DELZ+TS
   N3=TS-(RET/2.)/DELZ
   C1=1./(2./DELZ**2+2./DELR**2+1./1.4E-3/DELT)
   REWIND 8
   NO=NO1
   IF(SENSE LIGHT 1)57,63
57 DO 62 I=1,LONG
   DO 62 J=1,LAT
61 BLK(I,J)=T
62 BLK1(I,J)=T
63 DO 156 K=1,NIDT
   READ INPUT TAPE 8,190,(FLL(I),I=1,116)
   AI=0.0
   AII=AI
   DO 71 J=1,116
   A1=FLL(J)*DWAVE/RET*(1.-ABSMO(J))*ABSI(J)
   AI=AI+A1
   A2=FLL(J)*DWAVE/CHOR*(1.-ABSMO(J))*(1.-ABSI(J))*ABSII(J)
71 AII=AII+A2
   R=FOCAL*RADI(K)*AMUL/(DIST**2+ALT**2)**.5/5280.
   IF(R-3.5E-4)72,73,73
72 AI=AI*(R/3.5E-4)**2
   AII=AII*(R/3.5E-4)**2
73 T=T+DELT
   L1=1.+R/DELR
79 I=MID
      BIG=0.0
   J=2
   IJ=MID
```

```
      EYE PROBLEM PROGRAMED BY LAWTON BLACKBURN JR.
      JI=3
   83 IF(I-IJ)89,84,89
   84 IF(J-1)86,85,86
   85 IF(I-(MID-1))96,96,92
   86 IF(J-JI)104,87,87
   87 IF(I-J-(MID-1))88,96,88
   88 IF(I+J-(MID+1))100,92,100
   89 IF(J-1)90,100,90
   90 IF(I-J-(MID-1))108,104,108
   91 IF(I-IJ)96,92,92
   92 IJ=I
      JI=J
      I=I+1
      GO TO 114
   96 IJ=I
      JI=J
      I=I-1
      GO TO 114
  100 IJ=I
      JI=J
      J=J+1
      GO TO 114
  104 IJ=I
      JI=J
      J=J-1
      GO TO 114
  108 IF(I+J-(MID+1))91,104,91
  114 IF(J-L1)115,115,123
  115 IF(I-N2)116,121,123
  116 IF(I-N1)117,119,121
  117 IF(I-N3)123,119,119
  119 P1=CAF*AI/1.4E-3
      GO TO 1124
  121 P1=CAF*AII/1.4E-3
      GO TO 1124
  123 P1=0.0
 1124 IF(SENSE SWITCH 5)1125,124
 1125 PRINT 1126,AI,AII,P1
 1126 FORMAT(3E12.4)
  124 IF(J-1)129,129,132
  129 V3=BLK(I,J+1)
      V5=V3
  130 S=10.
      GO TO 134
  132 V5=BLK(I,J-1)
      V3=BLK(I,J+1)
  133 AA=J-1
      S=AA*DELR
  134 BKO=C1*((BLK(I-1,J)+BLK(I+1,J))/DELZ**2+(V5+V3)/DELR**2-(V5-V3)/2.
     1/S/DELR+BLK1(I,J)/1.4E-3/DELT+P1)
      DID=B KO-BLK(I,J)
      IF(ABSF(DID)-BIG)139,139,138
  138 BIG=ABSF(DID)
  139 BLK(I,J)=B KO
  140 IF(I-2)83,141,83
  141 IF(J-1)83,142,83
```

```
142 DO143NN=1,LATA
143 BLK(1,NN)=BLK(2,NN)
    DO145NN=2,LONGA
145 BLK(NN,LAT)=BLK(NN,LAT-1)
    DO147NN=1,LATA
147 BLK(LONG,NN)=BLK(LONG-1,NN)
    IF(SENSE SWITCH1)217,149
149 IF(BIG-TEST*BLK(MID,1))218,218,79
151 DO 153 NN=1,LONG
    DO 153 NM=1,LAT
153 BLK1(NN,NM)=BLK(NN,NM)
    IF(SENSE SWITCH 4)150,154
150 I = LEX(1)
    J = LEX(2)
    L = 0
400 L = L+1
    SIGMA(L) = EXPF(137.8712-46650.0/309.+BLK(I,J)+LOGF(DELT))
    OMEGA(L) = OMEGA(L)+SIGMA(L)
    I = LEX(2*L+1)
152 J = LEX(2*L+2)
    IF(I-0)400,154,400
154 IF(NO-NO1)155,158,155
155 NO=NO+1
156 CONTINUE
    END FILE 6
    END FILE 7
    END FILE 8
    KO =KO+1
    IF(DELTI(KO))208,171,12
158 COUNT = 0.0
    WRITE OUTPUT TAPE 6,304,((RUNNO(I),I=1,3),(CLASSF(I),I=1,3)),IPAGE
    IPAGE = IPAGE + 1
    COUNT = COUNT + 1.0
    WRITE OUTPUT TAPE 6,104,T,R
    COUNT = COUNT + 1.0
    KN = IM
414 WRITE OUTPUT TAPE 6,106,KN
    COUNT = COUNT + 1.0
    IF(COUNT - 59.0)415,425,415
415 JFK = 1
    KFJ = 5
416 WRITE OUTPUT TAPE 6,100,(BLK(KN,NK),NK = JFK,KFJ)
    COUNT = COUNT + 1.0
    IF(COUNT - 59.0)417,426,417
417 JFK = KFJ + 1
    KFJ = KFJ + 5
    IF(KFJ - LAT)416,416,418
418 IF(KFJ - LAT - 5)419,420,419
419 KFJ = LAT
    GO TO 416
420 IF(KN - IN)421,422,422
421 KN = KN + KK
    GO TO 414
422 WRITE OUTPUT TAPE 6,307
    COUNT = COUNT + 1.0
    IF(COUNT - 59.0)422,423,208
```

```
423 WRITE OUTPUT TAPE 6,309,(CLASSF(I),I=1,3)
    NO = 1
    IF(SENSE SWITCH 4)424,156
424 WRITE OUTPUT TAPE 6,304,((RUNNO(I),I=1,3),(CLASSF(I),I=1,3)),IPAGE
    IPAGE = IPAGE + 1
    WRITE OUTPUT TAPE 6,232,(OMEGA(I),LEX(2*I-1),LEX(2*I),I = 1,10)
    WRITE OUTPUT TAPE 6,308,(CLASSF(I),I=1,3)
    GO TO 156
425 WRITE OUTPUT TAPE 6,309,(CLASSF(I),I=1,3)
    WRITE OUTPUT TAPE 6,304,((RUNNO(I),I=1,3),(CLASSF(I),I=1,3)),IPAGE
    IPAGE = IPAGE + 1
    COUNT=1.0
    GO TO 415
426 WRITE OUTPUT TAPE 6,309,(CLASSF(I),I=1,3)
    WRITE OUTPUT TAPE 6,304,((RUNNO(I),I=1,3),(CLASSF(I),I=1,3)),IPAGE
    IPAGE = IPAGE + 1
    COUNT=1.0
    GO TO 417
165 WRITE OUTPUT TAPE 7,104,T
    DO 168 KN=IM,IN,KK
    WRITE OUTPUT TAPE 7,106,KN
168 WRITE OUTPUT TAPE 7,190,(BLK(KN,NK),NK=1,LAT )
    GO TO 149
171 IF(SENSE SWITCH 2)170,9
170 PAUSE 77777
172 GO TO 9
174 FORMAT(14F5.3)
175 FORMAT(20I3)
176 FORMAT(7F10.8)
178 FORMAT(7F10.1)
180 FORMAT(18F4.1)
182 FORMAT(7F10.6)
     FORMAT(5F8.6,6I4)
1    FORMAT(2F4.3)
186 FORMAT(F9.2,F8.3,F9.0,F5.2,F6.3,F7.3,F6.3,5F4.3)
189 FORMAT(7F10.7)
190 FORMAT(5E14.5)
191 FORMAT(5E14.7)
192 FORMAT(30H END OF RELAXATION FOR TIME = F7.6)
194 FORMAT(1H 8H TIME = F9.7,8H     R = E12.5)
196 FORMAT(6H   I = I2)
198 FORMAT(5H     5F15.6)
200 FORMAT(////)
208 PAUSE 123456
    GO TO 27
217 IF(NO-NO1)149,165,149
218 IF(SENSE SWITCH 1)219,151
219 IF(NO-NO1)151,220,151
220 WRITE OUTPUT TAPE 7,192,T
    GO TO 151
413 WRITE OUTPUT TAPE 6,304,((RUNNO(I),I=1,3),(CLASSF(I),I=1,3)),IPAGE
    IPAGE = IPAGE + 1
    WRITE OUTPUT TAPE 6,200
224 WRITE OUTPUT TAPE 6,228,YIELD,ALT,DIST,FNUMB,ANGLF,FOCAL,AMUL,AMFL
   1,AMFH,RELHU,WMFI,CAF,PET,CHOR,TEST,DELZ,DELR,NO1,IM,IN,KK,LONG,LAT
   2,DELTI(1),DELTI(2),DELTI(3),DELTI(4),DELTI(5),DELTI(6),DELTI(7),DE
```

```
   EYE PROBLEM PROGRAMED BY LAWTON BLACKBURN JR.

  3LTI(8)
   WRITE OUTPUT TAPE 6,200
   WRITE OUTPUT TAPE 6,230,(FTIMS(I),I=1,8)
   WRITE OUTPUT TAPE 6,305,(CLASSF(I),I=1,3)
   SUM=0.0
   GO TO 12
228 FORMAT( 9H YIELD = F9.2/9H ALT    = F10.3/9H DIST   = F10.0/9H FNUMB
  1 = F10.2/9H ANGLE = F10.3/9H FOCAL = F10.5/9H AMUL   = F10.3/9H AMF
  2L   = F10.3/9H AMFH   = F10.3/9H RELHU = F10.3/9H WMFI   = F10.3/9H C
  3AF    = F10.3/9H RET    = F10.6/9H CHOR   = F10.6/9H TEST   = F10.6/9H
  4 DELZ   = F10.6/9H DELR   = F10.6/9H NO1    = I10/9H IM     = I10/9H I
  5N     = I10/9H KK     = I10/9H LONG   = I10/9H LAT    = I10/12H DELTI(
  61) = F10.7/12H DELTI(2) = F10.7/12H DELTI(3) = F10.7/12H DELTI(4)
  7= F10.7/12H DELTI(5) = F10.7/12H DELTI(6) = F10.7/12H DELTI(7) = F
  810.7/12H DELTI(8) = F10.7)
230 FORMAT(12H FTIMS(1) = F10.7/12H FTIMS(2) = F10.7/12H FTIMS(3) =
  1F10.7/12H FTIMS(4) = F10.7/12H FTIMS(5) = F10.7/12H FTIMS(6) =
  2F10.7/12H FTIMS(7) = F10.7/12H FTIMS(8) = F10.7)
232 FORMAT(23H    OMEGA          I       J/(E12.5,3H   I3,3H   I3/))
300 FORMAT(3A6,3A6)
301 FORMAT(1H1 40X,3A6)
302 FORMAT(28X,3HSUM,26X,4HSUMD,25X,5HFTIME)
303 FORMAT(24X,E12.5,18X,E12.5,18X,E12.5)
304 FORMAT(1H1 10X,3A6,10X,3A6,21X,6H PAGE I4)
305 FORMAT(//////////// 40X,3A6)
307 FORMAT(/)
308 FORMAT(/////////////////////////////////////////////////////////40X,3A6)
309 FORMAT(40X,3A6)
   END(0,1,0,0,1,0,0,1,0,0,0,0,0,0,0)

   END (0,1,0,1,1)

   END FILE

   *N  END TAPE
```

TABLE 3

**PTRAN** (atmospheric transmission less water vapor) (from 350 to 1500 microns in increments of 10 microns) ( x $10^3$).

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 551 | 589 | 623 | 656 | 685 | 712 | 746 | 758 | 776 | 795 | 812 | 827 | 839 | 852 |
| 863 | 874 | 882 | 891 | 898 | 906 | 913 | 918 | 923 | 929 | 934 | 938 | 941 | 945 |
| 949 | 952 | 955 | 957 | 959 | 962 | 964 | 966 | 968 | 969 | 970 | 972 | 974 | 976 |
| 977 | 978 | 979 | 980 | 981 | 981 | 982 | 983 | 984 | 984 | 985 | 986 | 987 | 988 |
| 988 | 989 | 989 | 990 | 990 | 990 | 991 | 991 | 992 | 992 | 992 | 993 | 993 | 993 |
| 994 | 994 | 994 | 994 | 995 | 995 | 995 | 995 | 995 | 995 | 995 | 996 | 996 | 996 |
| 996 | 996 | 996 | 996 | 996 | 996 | 997 | 997 | 997 | 997 | 997 | 997 | 997 | 997 |
| 997 | 997 | 998 | 998 | 998 | 998 | 998 | 998 | 998 | 998 | 998 | 998 | 998 | 998 |
| 998 | 998 | 998 | 998 | | | | | | | | | | |

**QTRAN** (water vapor transmissivity) (from 350 to 1500 microns in increments of 10 microns) ( x $10^3$).

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 926 | 934 | 940 | 945 | 949 | 951 | 953 | 955 | 957 | 959 | 961 | 963 | 964 | 966 |
| 967 | 968 | 970 | 971 | 972 | 971 | 971 | 970 | 970 | 971 | 972 | 973 | 974 | 975 |
| 976 | 977 | 978 | 979 | 980 | 981 | 981 | 982 | 982 | 983 | 983 | 983 | 984 | 984 |
| 985 | 985 | 985 | 985 | 985 | 986 | 986 | 986 | 986 | 986 | 986 | 986 | 986 | 986 |
| 987 | 987 | 987 | 987 | 987 | 987 | 987 | 987 | 987 | 987 | 987 | 987 | 987 | 987 |
| 987 | 987 | 987 | 987 | 987 | 987 | 987 | 987 | 987 | 987 | 987 | 987 | 987 | 987 |
| 987 | 987 | 987 | 987 | 987 | 987 | 987 | 987 | 987 | 987 | 987 | 987 | 987 | 987 |
| 987 | 987 | 987 | 987 | 987 | 987 | 987 | 987 | 987 | 987 | 987 | 987 | 987 | 987 |
| 987 | 987 | 987 | 987 | | | | | | | | | | |

Absorption coefficient in ocular media x $10^3$. (ABSMO)

| | | | | | | |
|---|---|---|---|---|---|---|
| 1000000 | 1000000 | 1000000 | 1000000 | 1000000 | 1000000 | 0900000 |
| 0620000 | 0575000 | 0500000 | 0425000 | 0333000 | 0285000 | 0240000 |
| 0223000 | C185000 | 0160000 | 0130000 | 0115000 | 0100000 | 0090000 |
| 0075000 | 0060000 | 0050000 | 0037000 | 0033000 | 0033000 | 0033000 |
| 0033000 | 0033000 | 0033000 | 0033000 | 0033000 | 0033000 | 0033000 |
| 0033000 | 0033000 | 0033000 | 0033000 | 0033000 | 0033000 | 0033000 |
| 0033000 | 0033000 | 0033000 | 0033000 | 0033000 | 0033000 | 0033000 |
| 0033000 | 0033000 | 0033000 | 0033000 | 0035000 | 0040000 | 0050000 |
| 0060000 | 0075000 | 0088000 | 0110000 | 0150000 | 0290000 | 0480000 |
| 0534000 | 0575000 | 0582000 | 0582000 | 0582000 | 0550000 | 0525000 |
| 0475000 | 0400000 | 0300000 | 0250000 | 0210000 | 0200000 | 0210000 |
| 0225000 | 0260000 | 0290000 | 0360000 | 0410000 | 0680000 | 0810000 |
| 0880000 | 0900000 | 0920000 | 0930000 | 0940000 | 0950000 | 0940000 |
| 0930000 | 0920000 | 0910000 | 0905000 | 0900000 | 0905000 | 0910000 |
| 0920000 | 0940000 | 0970000 | 0980000 | 0985000 | 0990000 | 0993000 |
| 0995000 | 1000000 | 1000000 | 1000000 | 1000000 | 1000000 | 1000000 |
| 1000000 | 1000000 | 1000000 | 1000000 | | | |

TABLE 4

Reduced height, $h_1$ and decimal percent, of th^ atmosphere for a station that is k km above sea level. (First three columns of this table from Kuiper, G.P., The Atmosphere of the Earth and Planets, 1952.)

| k (km) | $h_1$ (Winter) (km) | $h_1$ (Summer) (km) | Decimal Percent (Winter) | Decimal Percent (Summer) |
|---|---|---|---|---|
| 0 | 8.03 | 8.05 | 1.00 | 1.00 |
| 1 | 7.09 | 7.15 | 0.884 | 0.890 |
| 2 | 6.26 | 6.34 | 0.780 | 0.787 |
| 3 | 5.51 | 5.61 | 0.686 | 0.697 |
| 4 | 4.83 | 4.95 | 0.602 | 0.615 |
| 5 | 4.23 | 4.36 | 0.526 | 0.541 |
| 6 | 3.68 | 3.82 | 0.458 | 0.475 |
| 7 | 3.20 | 3.34 | 0.399 | 0.415 |
| 8 | 2.76 | 2.91 | 0.344 | 0.361 |
| 9 | 2.38 | 2.53 | 0.296 | 0.314 |
| 10 | 2.04 | 2.18 | 0.254 | 0.281 |
| 12 | 1.45 | 1.61 | 0.180 | 0.200 |
| 14 | 1.09 | 1.19 | 0.136 | 0.128 |
| 16 | 0.79 | 0.88 | 0.098 | 0.011 |
| 18 | 0.58 | 0.65 | 0.072 | 0.081 |
| 20 | 0.42 | 0.48 | 0.053 | 0.060 |
| 25 | 0.19 | 0.22 | 0.024 | 0.027 |
| 30 | 0.09 | 0.11 | 0.011 | 0.014 |
| 35 | 0.04 | 0.05 | 0.005 | 0.006 |
| 40 | 0.02 | 0.02 | 0.003 | 0.003 |

The above table is used to find constants $M_L$ and $M_H$ (designated as AMFL and AMFH in program).

TABLE 5
(Read Across)

Absorption coefficient in PE x $10^3$. (ABSI)

| | | | | | | |
|---|---|---|---|---|---|---|
| 0853000 | 0825000 | 0805000 | 0775000 | 0750000 | 0730000 | 0723000 |
| 0717000 | 0714000 | 0712000 | 0710000 | 0700000 | 0687000 | 0675000 |
| 0665000 | 0650000 | 0625000 | 0600000 | 0575000 | 0550000 | 0530000 |
| 0505000 | 0480000 | 0457000 | 0435000 | 0420000 | 0400000 | 0385000 |
| 0370000 | 0355000 | 0343000 | 0333000 | 0315000 | 0300000 | 0287000 |
| 0273000 | 0260000 | 0250000 | 0240000 | 0225000 | 0215000 | 0205000 |
| 0195000 | 0187000 | 0180000 | 0175000 | 0168000 | 0162000 | 0157000 |
| 0152000 | 0150000 | 0145000 | 0140000 | 0137000 | 0130000 | 0125000 |
| 0120000 | 0120000 | 0120000 | 0120000 | 0120000 | 0120000 | 0120000 |
| 0120000 | 0120000 | 0120000 | 0120000 | 0120000 | 0120000 | 0120000 |
| 0120000 | 0120000 | 0120000 | 0120000 | 0120000 | 0120000 | 0120000 |
| 0120000 | 0120000 | 0120000 | 0120000 | 0110000 | 0110000 | 0110000 |
| 0110000 | 0110000 | 0120000 | 0125000 | 0134000 | 0140000 | 0145000 |
| 0140000 | 0137000 | 0135000 | 0127000 | 0120000 | 0110000 | 0107000 |
| 0102000 | 0100000 | 0100000 | 0113000 | 0125000 | 0140000 | 0150000 |
| 0160000 | 0175000 | 0190000 | 0200000 | 0215000 | 0230000 | 0350000 |
| 0510000 | 0675000 | 0840000 | 0975000 | | | |

Absorption coefficient in choroid x $10^3$. (ABSII)

| | | | | | | |
|---|---|---|---|---|---|---|
| 0923000 | 0923000 | 0923000 | 0920000 | 0915000 | 0910000 | 0905000 |
| 0900000 | 0890000 | 0882000 | 0875000 | 0860000 | 0890000 | 0820000 |
| 0795000 | 0775000 | 0765000 | 0760000 | 0750000 | 0745000 | 0740000 |
| 0733000 | 0720000 | 0705000 | 0685000 | 0660000 | 0642000 | 0625000 |
| 0605000 | 0583000 | 0555000 | 0547000 | 0540000 | 0533000 | 0527000 |
| 0520000 | 0500000 | 0475000 | 0450000 | 0417000 | 0390000 | 0375000 |
| 0370000 | 0360000 | 0350000 | 0345000 | 0340000 | 0330000 | 0323000 |
| 0317000 | 0310000 | 0295000 | 0283000 | 0270000 | 0255000 | 0245000 |
| 0240000 | 0230000 | 0227000 | 0224000 | 0222000 | 0230000 | 0240000 |
| 0250000 | 0257000 | 0270000 | 0265000 | 0260000 | 0255000 | 0245000 |
| 0230000 | 0220000 | 0210000 | 0197000 | 0187000 | 0180000 | 0175000 |
| 0170000 | 0170000 | 0170000 | 0175000 | 0195000 | 0225000 | 0253000 |
| 0285000 | 0315000 | 0325000 | 0334000 | 0340000 | 0340000 | 0340000 |
| 0340000 | 0335000 | 0330000 | 0320000 | 0315000 | 0300000 | 0295000 |
| 0285000 | 0280000 | 0275000 | 0303000 | 0340000 | 0390000 | 0450000 |
| 0520000 | 0690000 | 0795000 | 0870000 | 0935000 | 0975000 | 0975000 |
| 0975000 | 0975000 | 0975000 | 0975000 | | | |

RUN G 4



```
YIELD  =     2.50
ALT    =     0.
DIST   =        1.
FNUMB  =      8.50
ANGLE  =     0.
FOCAL  =   1.70000
AMUL   =     1.000
AMFL   =     1.000
AMFH   =     0.
RELHU  =     0.500
WMFI   =     0.
CAF    =     1.000
RET    =  0.001000
CHOR   =  0.010000
TEST   =  0.010000
DELZ   =  0.001000
DELR   =  0.001000
NO1    =         1
IM     =         1
IN     =        49
KK     =         3
LONG   =        49
LAT    =        25
DELTI(1) =  0.0000020
DELTI(2) =  0.0000200
DELTI(3) =  0.0002000
DELTI(4) =  0.0020000
DELTI(5) =  0.0200000
DELTI(6) =  0.2000000
DELTI(7) = -0.
DELTI(8) = -0.
```

```
FTIMS(1) =  0.0000100
FTIMS(2) =  0.0001000
FTIMS(3) =  0.0010000
FTIMS(4) =  0.0100000
FTIMS(5) =  0.1000000
FTIMS(6) =  0.5000000
FTIMS(7) = -0.
FTIMS(8) = -0.
```

RUN G 4

TIME = 0.0000020 R = 0.78966E-02

I = 1

| | | | | |
|---|---|---|---|---|
| 0. | 0. | 0. | 0. | 0. |
| 0. | 0. | 0. | 0. | 0. |
| 0. | 0. | 0. | 0. | 0. |
| 0. | 0. | 0. | 0. | 0. |
| 0. | 0. | 0. | 0. | 0. |

I = 4

| | | | | |
|---|---|---|---|---|
| 0. | 0. | 0. | 0. | 0. |
| 0. | 0. | 0. | 0. | 0. |
| 0. | 0. | 0. | 0. | 0. |
| 0. | 0. | 0. | 0. | 0. |
| 0. | 0. | 0. | 0. | 0. |

I = 7

| | | | | |
|---|---|---|---|---|
| 0. | 0. | 0. | 0. | 0. |
| 0. | 0. | 0. | 0. | 0. |
| 0. | 0. | 0. | 0. | 0. |
| 0. | 0. | 0. | 0. | 0. |
| 0. | 0. | 0. | 0. | 0. |

I = 10

| | | | | |
|---|---|---|---|---|
| 0.15304E-35 | 0.14907E-35 | 0.15205E-35 | 0.14445E-35 | 0.97883E-37 |
| 0.14246E-35 | 0.82105E-37 | 0.14196E-35 | 0.33098E-37 | 0. |
| 0. | 0. | 0. | 0. | 0. |
| 0. | 0. | 0. | 0. | 0. |
| 0. | 0. | 0. | 0. | 0. |

I = 13

| | | | | |
|---|---|---|---|---|
| 0.70935E-28 | 0.69320E-28 | 0.70493E-28 | 0.67830E-28 | 0.34972E-29 |
| 0.67053E-28 | 0.27577E-29 | 0.66837E-28 | 0.10394E-29 | 0.12683E-31 |
| 0.78622E-34 | 0.69278E-36 | 0.22892E-38 | 0. | 0. |
| 0. | 0. | 0. | 0. | 0. |
| 0. | 0. | 0. | 0. | 0. |

I = 16

| | | | | |
|---|---|---|---|---|
| 0.32881E-20 | 0.32369E-20 | 0.32675E-20 | 0.31785E-20 | 0.11227E-21 |
| 0.31567E-20 | 0.77623E-22 | 0.31471E-20 | 0.24463E-22 | 0.34140E-24 |
| 0.13466E-26 | 0.17209E-28 | 0.59825E-31 | 0.54929E-33 | 0.18024E-35 |
| 0.13594E-37 | 0. | 0. | 0. | 0. |
| 0. | 0. | 0. | 0. | 0. |

I = 19

| | | | | |
|---|---|---|---|---|
| 0.15237E-12 | 0.15055E-12 | 0.15143E-12 | 0.14931E-12 | 0.28225E-14 |
| 0.14864E-12 | 0.11958E-14 | 0.14821E-12 | 0.76846E-15 | 0.11057E-16 |
| 0.42292E-19 | 0.35648E-21 | 0.12240E-23 | 0.79536E-26 | 0.25851E-28 |
| 0.14341E-30 | 0.45100E-33 | 0.22471E-35 | 0.69132E-38 | 0. |
| 0. | 0. | 0. | 0. | 0. |

I = 22

| | | | | |
|---|---|---|---|---|
| 0.70602E-05 | 0.70313E-05 | 0.70163E-05 | 0.69990E-05 | 0.55506E-07 |
| 0.70003E-05 | 0.56322E-07 | 0.69803E-05 | 0.36193E-07 | 0.23683E-09 |
| 0.87201E-12 | 0.39553E-14 | 0.13119E-16 | 0.51287E-19 | 0.16185E-21 |
| 0.58383E-24 | 0.17899E-26 | 0.61405E-29 | 0.18477E-31 | 0.61248E-34 |
| 0.18191E-36 | 0. | 0. | 0. | 0. |

I = 25

| | | | | |
|---|---|---|---|---|
| 0.91084E 00 | 0.91084E 00 | 0.91085E 00 | 0.91085E 00 | 0.91085E 00 |
| 0.91085E 00 | 0.91085E 00 | 0.90817E 00 | 0.23645E-02 | 0.62020E-05 |
| 0.16363E-07 | 0.43379E-10 | 0.11545E-12 | 0.30831E-15 | 0.82567E-18 |
| 0.22167E-20 | 0.59640E-23 | 0.16076E-25 | 0.43409E-28 | 0.11739E-30 |
| 0.31787E-33 | 0.86180E-36 | 0.23385E-38 | 0. | 0. |

I = 28

| | | | | |
|---|---|---|---|---|
| 0.57765E-01 | 0.57765E-01 | 0.57765E-01 | 0.57764E-01 | 0.57765E-01 |
| 0.57765E-01 | 0.57765E-01 | 0.57595E-01 | 0.15034E-03 | 0.39536E-06 |

| | | | | |
|---|---|---|---|---|
| 0.10458E-08 | 0.27794E-11 | 0.74163E-14 | 0.19855E-16 | 0.53307E-19 |
| 0.14347E-21 | 0.38698E-24 | 0.10457E-26 | 0.28307E-29 | 0.76738E-32 |
| 0.20831E-34 | 0.56616E-37 | 0. | 0. | 0. |

I = 31

| | | | | |
|---|---|---|---|---|
| 0.57766E-01 | 0.57766E-01 | 0.57766E-01 | 0.57766E-01 | 0.57766E-01 |
| 0.57766E-01 | 0.57765E-01 | 0.57595E-01 | 0.15034E-03 | 0.39535E-06 |
| 0.10457E-08 | 0.27793E-11 | 0.74157E-14 | 0.19853E-16 | 0.53300E-19 |
| 0.14345E-21 | 0.38690E-24 | 0.10455E-26 | 0.28298E-29 | 0.76710E-32 |
| 0.20822E-34 | 0.56588E-37 | 0. | 0. | 0. |

I = 34

| | | | | |
|---|---|---|---|---|
| 0.57765E-01 | 0.57765E-01 | 0.57765E-01 | 0.57765E-01 | 0.57765E-01 |
| 0.57765E-01 | 0.57765E-01 | 0.57595E-01 | 0.14993E-03 | 0.39210E-06 |
| 0.10343E-08 | 0.27340E-11 | 0.72756E-14 | 0.19373E-16 | 0.51876E-19 |
| 0.13887E-21 | 0.37360E-24 | 0.10042E-26 | 0.27113E-29 | 0.73114E-32 |
| 0.19797E-34 | 0.53524E-37 | 0. | 0. | 0. |

I = 37

| | | | | |
|---|---|---|---|---|
| 0.44661E-06 | 0.44661E-06 | 0.44661E-06 | 0.44661E-06 | 0.44661E-06 |
| 0.44661E-06 | 0.44659E-06 | 0.44268E-06 | 0.34328E-08 | 0.90023E-11 |
| 0.23747E-13 | 0.62881E-16 | 0.16748E-18 | 0.59482E-21 | 0.23922E-23 |
| 0.74764E-26 | 0.25915E-28 | 0.77469E-31 | 0.25175E-33 | 0.73628E-36 |
| 0.23092E-38 | 0. | 0. | 0. | 0. |

I = 40

| | | | | |
|---|---|---|---|---|
| 0.96400E-14 | 0.96402E-14 | 0.96402E-14 | 0.96402E-14 | 0.96402E-14 |
| 0.96402E-14 | 0.96389E-14 | 0.94729E-14 | 0.14627E-15 | 0.95552E-18 |
| 0.46929E-20 | 0.19944E-22 | 0.77670E-25 | 0.27901E-27 | 0.98857E-30 |
| 0.28261E-32 | 0.11873E-34 | 0.34997E-37 | 0. | 0. |
| 0. | 0. | 0. | 0. | 0. |

I = 43

| | | | | |
|---|---|---|---|---|
| 0.20808E-21 | 0.20808E-21 | 0.20808E-21 | 0.20808E-21 | 0.20807E-21 |
| 0.20807E-21 | 0.20801E-21 | 0.20272E-21 | 0.46679E-23 | 0.40609E-25 |
| 0.24915E-27 | 0.12701E-29 | 0.57688E-32 | 0.24078E-34 | 0.94876E-37 |
| 0. | 0. | 0. | 0. | 0. |
| 0. | 0. | 0. | 0. | 0. |

I = 46

| | | | | |
|---|---|---|---|---|
| 0.44905E-29 | 0.44907E-29 | 0.44907E-29 | 0.44907E-29 | 0.44907E-29 |
| 0.44907E-29 | 0.44885E-29 | 0.43389E-29 | 0.13263E-30 | 0.16414E-32 |
| 0.13769E-34 | 0.92333E-37 | 0. | 0. | 0. |
| 0. | 0. | 0. | 0. | 0. |
| 0. | 0. | 0. | 0. | 0. |

I = 49

| | | | | |
|---|---|---|---|---|
| 0.34900E-34 | 0.34902E-34 | 0.34902E-34 | 0.34902E-34 | 0.34902E-34 |
| 0.34902E-34 | 0.34880E-34 | 0.33539E-34 | 0.11907E-35 | 0.17042E-37 |
| 0. | 0. | 0. | 0. | 0. |
| 0. | 0. | 0. | 0. | 0. |
| 0. | 0. | 0. | 0. | 0. |

TIME = 0.0000300 R = 0.24619E-01

I = 1

| | | | | |
|---|---|---|---|---|
| 0.15589E-33 | 0.15540E-33 | 0.14631E-33 | 0.12610E-33 | 0.96962E-34 |
| 0.96530E-34 | 0.66356E-34 | 0.82898E-34 | 0.50409E-34 | 0.64494E-34 |
| 0.37374E-34 | 0.54505E-34 | 0.29132E-34 | 0.48003E-34 | 0.23054E-34 |
| 0.44211E-34 | 0.18429E-34 | 0.42713E-34 | 0.14397E-34 | 0.41690E-34 |
| 0.10443E-34 | 0.41069E-34 | 0.75889E-35 | 0.64515E-34 | 0. |

I = 4

| | | | | |
|---|---|---|---|---|
| 0.21866E-30 | 0.21861E-30 | 0.20672E-30 | 0.17868E-30 | 0.13489E-30 |
| 0.13821E-30 | 0.89774E-31 | 0.11979E-30 | 0.67231E-31 | 0.93372E-31 |
| 0.49088E-31 | 0.79440E-31 | 0.37504E-31 | 0.70412E-31 | 0.28829E-31 |
| 0.65321E-31 | 0.22044E-31 | 0.63635E-31 | 0.15984E-31 | 0.62641E-31 |
| 0.99894E-32 | 0.62222E-31 | 0.76589E-32 | 0.94740E-31 | 0.94740E-31 |

I = 7

| | | | | |
|---|---|---|---|---|
| 0.11814E-25 | 0.11863E-25 | 0.11324E-25 | 0.98147E-26 | 0.71518E-26 |
| 0.77880E-26 | 0.45262E-26 | 0.68653E-26 | 0.32907E-26 | 0.53751E-26 |
| 0.23219E-26 | 0.46269E-26 | 0.16906E-26 | 0.41476E-26 | 0.12043E-26 |
| 0.38957E-26 | 0.80515E-27 | 0.38470E-26 | 0.43440E-27 | 0.38390E-26 |
| 0.43458E-27 | 0.38396E-26 | 0.47020E-27 | 0.54968E-26 | 0.54968E-26 |

I = 10

| | | | | |
|---|---|---|---|---|
| 0.64266E-21 | 0.64396E-21 | 0.62061E-21 | 0.54231E-21 | 0.37432E-21 |
| 0.44185E-21 | 0.21990E-21 | 0.39835E-21 | 0.15241E-21 | 0.31416E-21 |
| 0.10120E-21 | 0.27406E-21 | 0.66791E-22 | 0.24885E-21 | 0.39355E-22 |
| 0.23696E-21 | 0.26981E-22 | 0.23680E-21 | 0.26997E-22 | 0.23684E-21 |
| 0.27018E-22 | 0.23687E-21 | 0.28856E-22 | 0.31830E-21 | 0.31830E-21 |

I = 13

| | | | | |
|---|---|---|---|---|
| 0.34637E-16 | 0.34781E-16 | 0.33885E-16 | 0.29958E-16 | 0.19281E-16 |
| 0.25468E-16 | 0.10089E-16 | 0.23496E-16 | 0.63865E-17 | 0.18703E-16 |
| 0.37083E-17 | 0.16552E-16 | 0.18295E-17 | 0.15240E-16 | 0.17178E-17 |
| 0.14616E-16 | 0.16773E-17 | 0.14608E-16 | 0.16784E-17 | 0.14610E-16 |
| 0.16796E-17 | 0.14612E-16 | 0.17703E-17 | 0.18396E-16 | 0.18396E-16 |

I = 16

| | | | | |
|---|---|---|---|---|
| 0.18752E-11 | 0.18777E-11 | 0.18481E-11 | 0.16721E-11 | 0.96772E-12 |
| 0.14856E-11 | 0.41329E-12 | 0.14098E-11 | 0.21038E-12 | 0.11360E-11 |
| 0.12517E-12 | 0.10182E-11 | 0.11366E-12 | 0.93977E-12 | 0.10677E-12 |
| 0.90133E-12 | 0.10427E-12 | 0.90098E-12 | 0.10434E-12 | 0.90109E-12 |
| 0.10442E-12 | 0.90118E-12 | 0.10856E-12 | 0.10612E-11 | 0.10612E-11 |

I = 19

| | | | | |
|---|---|---|---|---|
| 0.10081E-06 | 0.10095E-06 | 0.10028E-06 | 0.93582E-07 | 0.46709E-07 |
| 0.88533E-07 | 0.12793E-07 | 0.86317E-07 | 0.10054E-07 | 0.70003E-07 |
| 0.85464E-08 | 0.62773E-07 | 0.72698E-08 | 0.57940E-07 | 0.66369E-08 |
| 0.55575E-07 | 0.64817E-08 | 0.55564E-07 | 0.64864E-08 | 0.55569E-07 |
| 0.64909E-08 | 0.55574E-07 | 0.66546E-08 | 0.61111E-07 | 0.61111E-07 |

I = 22

| | | | | |
|---|---|---|---|---|
| 0.53874E-02 | 0.53849E-02 | 0.53773E-02 | 0.52854E-02 | 0.51831E-02 |
| 0.52912E-02 | 0.51842E-02 | 0.52160E-02 | 0.42339E-02 | 0.42685E-02 |
| 0.41343E-02 | 0.38386E-02 | 0.36953E-02 | 0.35605E-02 | 0.33411E-02 |
| 0.34262E-02 | 0.33323E-02 | 0.34261E-02 | 0.33326E-02 | 0.34264E-02 |
| 0.33329E-02 | 0.34266E-02 | 0.33371E-02 | 0.35133E-02 | 0.35133E-02 |

I = 25

| | | | | |
|---|---|---|---|---|
| 0.67417E 01 | 0.67419E 01 | 0.67422E 01 | 0.67422E 01 | 0.67423E 01 |
| 0.67422E 01 | 0.67412E 01 | 0.67065E 01 | 0.58941E 01 | 0.58633E 01 |
| 0.58470E 01 | 0.54453E 01 | 0.54222E 01 | 0.51675E 01 | 0.50141E 01 |
| 0.50096E 01 | 0.50095E 01 | 0.50095E 01 | 0.50095E 01 | 0.50095E 01 |
| 0.50095E 01 | 0.50095E 01 | 0.50095E 01 | 0.50095E 01 | 0.50095E 01 |

I = 28

| | | | | |
|---|---|---|---|---|
| 0.44162E-00 | 0.44163E-00 | 0.44162E-00 | 0.44153E-00 | 0.44163E-00 |
| 0.44156E-00 | 0.44156E-00 | 0.43918E-00 | 0.38593E-00 | 0.38380E-00 |

| | | | | |
|---|---|---|---|---|
| Ø.38277E-ØØ | Ø.35620E-ØØ | Ø.35471E-ØØ | Ø.33773E-ØØ | Ø.32725E-ØØ |
| Ø.32687E-ØØ | Ø.32693E-ØØ | Ø.32686E-ØØ | Ø.32693E-ØØ | Ø.32686E-ØØ |
| Ø.32693E-ØØ | Ø.32686E-ØØ | Ø.32693E-ØØ | Ø.32686E-ØØ | Ø.32686E-ØØ |
| I = 31 | | | | |
| Ø.44153E-ØØ | Ø.44153E-ØØ | Ø.44153E-ØØ | Ø.44152E-ØØ | Ø.44152E-ØØ |
| Ø.44152E-ØØ | Ø.44141E-ØØ | Ø.43913E-ØØ | Ø.38582E-ØØ | Ø.38377E-ØØ |
| Ø.38267E-ØØ | Ø.35618E-ØØ | Ø.35462E-ØØ | Ø.33771E-ØØ | Ø.32717E-ØØ |
| Ø.32686E-ØØ | Ø.32685E-ØØ | Ø.32685E-ØØ | Ø.32685E-ØØ | Ø.32685E-ØØ |
| Ø.32685E-ØØ | Ø.32685E-ØØ | Ø.32685E-ØØ | Ø.32685E-ØØ | Ø.32685E-ØØ |
| I = 34 | | | | |
| Ø.44118E-ØØ | Ø.44119E-ØØ | Ø.44119E-ØØ | Ø.44120E-ØØ | Ø.44120E-ØØ |
| Ø.44119E-ØØ | Ø.44112E-ØØ | Ø.43881E-ØØ | Ø.38555E-ØØ | Ø.38349E-ØØ |
| Ø.38240E-ØØ | Ø.35594E-ØØ | Ø.35439E-ØØ | Ø.33749E-ØØ | Ø.32696E-ØØ |
| Ø.32664E-ØØ | Ø.32664E-ØØ | Ø.32663E-ØØ | Ø.32664E-ØØ | Ø.32663E-ØØ |
| Ø.32664E-ØØ | Ø.32663E-ØØ | Ø.32664E-ØØ | Ø.32663E-ØØ | Ø.32663E-ØØ |
| I = 37 | | | | |
| Ø.34370E-Ø3 | Ø.34370E-Ø3 | Ø.34370E-Ø3 | Ø.34369E-Ø3 | Ø.34369E-Ø3 |
| Ø.34368E-Ø3 | Ø.34342E-Ø3 | Ø.33873E-Ø3 | Ø.28280E-Ø3 | Ø.27844E-Ø3 |
| Ø.27599E-Ø3 | Ø.25018E-Ø3 | Ø.24196E-Ø3 | Ø.22093E-Ø3 | Ø.21871E-Ø3 |
| Ø.21205E-Ø3 | Ø.21812E-Ø3 | Ø.21205E-Ø3 | Ø.21814E-Ø3 | Ø.21207E-Ø3 |
| Ø.21815E-Ø3 | Ø.21208E-Ø3 | Ø.21791E-Ø3 | Ø.20208E-Ø3 | Ø.20208E-Ø3 |
| I = 40 | | | | |
| Ø.64635E-Ø8 | Ø.64645E-Ø8 | Ø.64648E-Ø8 | Ø.64648E-Ø8 | Ø.64647E-Ø8 |
| Ø.64638E-Ø8 | Ø.64493E-Ø8 | Ø.62976E-Ø8 | Ø.53552E-Ø8 | Ø.52027E-Ø8 |
| Ø.51201E-Ø8 | Ø.46634E-Ø8 | Ø.42322E-Ø8 | Ø.94136E-Ø9 | Ø.35643E-Ø8 |
| Ø.41346E-Ø9 | Ø.35373E-Ø8 | Ø.41280E-Ø9 | Ø.35377E-Ø8 | Ø.41311E-Ø9 |
| Ø.35380E-Ø8 | Ø.41337E-Ø9 | Ø.35281E-Ø8 | Ø.25265E-Ø9 | Ø.25265E-Ø9 |
| I = 43 | | | | |
| Ø.12062E-12 | Ø.12062E-12 | Ø.12061E-12 | Ø.12060E-12 | Ø.12059E-12 |
| Ø.12055E-12 | Ø.12005E-12 | Ø.11635E-12 | Ø.10079E-12 | Ø.96977E-13 |
| Ø.94815E-13 | Ø.86345E-13 | Ø.74934E-13 | Ø.24442E-13 | Ø.59161E-13 |
| Ø.15071E-13 | Ø.57761E-13 | Ø.94395E-14 | Ø.57361E-13 | Ø.66453E-14 |
| Ø.57372E-13 | Ø.66497E-14 | Ø.57117E-13 | Ø.40674E-14 | Ø.40674E-14 |
| I = 46 | | | | |
| Ø.22453E-17 | Ø.22463E-17 | Ø.22467E-17 | Ø.22467E-17 | Ø.22465E-17 |
| Ø.22450E-17 | Ø.22310E-17 | Ø.21507E-17 | Ø.18902E-17 | Ø.18021E-17 |
| Ø.17527E-17 | Ø.15913E-17 | Ø.13393E-17 | Ø.55349E-18 | Ø.10029E-17 |
| Ø.38141E-18 | Ø.96282E-18 | Ø.28819E-18 | Ø.94315E-18 | Ø.19737E-18 |
| Ø.93235E-18 | Ø.10700E-18 | Ø.92459E-18 | Ø.65479E-19 | Ø.65479E-19 |
| I = 49 | | | | |
| Ø.16154E-20 | Ø.16165E-20 | Ø.16169E-20 | Ø.16170E-20 | Ø.16168E-20 |
| Ø.16153E-20 | Ø.16030E-20 | Ø.15409E-20 | Ø.13652E-20 | Ø.12951E-20 |
| Ø.12526E-20 | Ø.11343E-20 | Ø.93961E-21 | Ø.43388E-21 | Ø.68364E-21 |
| Ø.31115E-21 | Ø.64972E-21 | Ø.24858E-21 | Ø.63112E-21 | Ø.18837E-21 |
| Ø.61836E-21 | Ø.12886E-21 | Ø.60701E-21 | Ø.42790E-22 | Ø. |

TIME = 0.0008900 R = 0.78037E-01

I = 1

| | | | | |
|---|---|---|---|---|
| 0.25187E-12 | 0.24429E-12 | 0.23456E-12 | 0.22136E-12 | 0.20434E-12 |
| 0.18407E-12 | 0.16183E-12 | 0.13920E-12 | 0.11765E-12 | 0.98242E-13 |
| 0.81461E-13 | 0.67398E-13 | 0.55734E-13 | 0.46262E-13 | 0.38438E-13 |
| 0.32252E-13 | 0.26958E-13 | 0.23051E-13 | 0.19221E-13 | 0.17191E-13 |
| 0.14250E-13 | 0.15255E-13 | 0.14220E-13 | 0.26076E-13 | 0. |

I = 4

| | | | | |
|---|---|---|---|---|
| 0.55691E-11 | 0.54417E-11 | 0.52548E-11 | 0.49797E-11 | 0.46127E-11 |
| 0.41674E-11 | 0.36724E-11 | 0.31645E-11 | 0.26785E-11 | 0.22405E-11 |
| 0.18607E-11 | 0.15434E-11 | 0.12782E-11 | 0.10655E-11 | 0.88499E-12 |
| 0.74970E-12 | 0.62173E-12 | 0.54608E-12 | 0.43819E-12 | 0.42438E-12 |
| 0.30254E-12 | 0.40705E-12 | 0.31921E-12 | 0.77718E-12 | 0.77718E-12 |

I = 7

| | | | | |
|---|---|---|---|---|
| 0.65116E-09 | 0.64692E-09 | 0.63185E-09 | 0.60346E-09 | 0.56256E-09 |
| 0.51094E-09 | 0.45217E-09 | 0.39102E-09 | 0.33193E-09 | 0.27872E-09 |
| 0.23214E-09 | 0.19386E-09 | 0.16056E-09 | 0.13586E-09 | 0.11132E-09 |
| 0.98730E-10 | 0.76391E-10 | 0.78146E-10 | 0.47046E-10 | 0.74149E-10 |
| 0.47880E-10 | 0.80763E-10 | 0.63883E-10 | 0.13771E-09 | 0.13771E-09 |

I = 10

| | | | | |
|---|---|---|---|---|
| 0.72859E-07 | 0.71679E-07 | 0.69790E-07 | 0.66797E-07 | 0.62511E-07 |
| 0.57006E-07 | 0.50648E-07 | 0.43974E-07 | 0.37463E-07 | 0.31689E-07 |
| 0.26444E-07 | 0.22530E-07 | 0.18342E-07 | 0.16582E-07 | 0.12221E-07 |
| 0.13706E-07 | 0.92612E-08 | 0.13516E-07 | 0.91956E-08 | 0.13538E-07 |
| 0.93802E-08 | 0.14408E-07 | 0.11648E-07 | 0.21785E-07 | 0.21785E-07 |

I = 13

| | | | | |
|---|---|---|---|---|
| 0.67820E-05 | 0.67603E-05 | 0.66527E-05 | 0.64309E-05 | 0.60770E-05 |
| 0.55932E-05 | 0.50169E-05 | 0.44026E-05 | 0.37771E-05 | 0.32725E-05 |
| 0.26910E-05 | 0.25033E-05 | 0.17532E-05 | 0.22375E-05 | 0.16536E-05 |
| 0.21543E-05 | 0.16123E-05 | 0.21260E-05 | 0.16027E-05 | 0.21273E-05 |
| 0.16223E-05 | 0.22116E-05 | 0.18663E-05 | 0.29360E-05 | 0.29360E-05 |

I = 16

| | | | | |
|---|---|---|---|---|
| 0.53999E-03 | 0.53643E-03 | 0.52722E-03 | 0.51328E-03 | 0.49040E-03 |
| 0.45654E-03 | 0.41579E-03 | 0.37418E-03 | 0.31915E-03 | 0.30890E-03 |
| 0.25608E-03 | 0.28865E-03 | 0.24061E-03 | 0.27262E-03 | 0.22919E-03 |
| 0.26307E-03 | 0.22411E-03 | 0.26015E-03 | 0.22308E-03 | 0.26009E-03 |
| 0.22428E-03 | 0.26491E-03 | 0.24000E-03 | 0.30855E-03 | 0.30855E-03 |

I = 19

| | | | | |
|---|---|---|---|---|
| 0.30352E-01 | 0.30348E-01 | 0.30125E-01 | 0.29695E-01 | 0.28944E-01 |
| 0.27509E-01 | 0.25498E-01 | 0.25706E-01 | 0.23799E-01 | 0.23915E-01 |
| 0.22244E-01 | 0.22419E-01 | 0.20892E-01 | 0.21160E-01 | 0.19895E-01 |
| 0.20451E-01 | 0.19513E-01 | 0.20269E-01 | 0.19448E-01 | 0.20254E-01 |
| 0.19470E-01 | 0.20347E-01 | 0.19828E-01 | 0.21319E-01 | 0.21319E-01 |

I = 22

| | | | | |
|---|---|---|---|---|
| 0.93170E 00 | 0.93171E 00 | 0.92995E 00 | 0.92486E 00 | 0.92591E 00 |
| 0.91924E 00 | 0.90679E 00 | 0.87894E 00 | 0.84459E 00 | 0.81447E 00 |
| 0.79068E 00 | 0.76472E 00 | 0.74318E 00 | 0.72236E 00 | 0.70815E 00 |
| 0.69955E 00 | 0.69674E 00 | 0.69491E 00 | 0.69514E 00 | 0.69442E 00 |
| 0.69498E 00 | 0.69426E 00 | 0.69477E 00 | 0.69346E 00 | 0.69346E 00 |

I = 25

| | | | | |
|---|---|---|---|---|
| 0.41601E 01 | 0.41624E 01 | 0.41585E 01 | 0.41582E 01 | 0.41495E 01 |
| 0.41305E 01 | 0.40767E 01 | 0.39702E 01 | 0.38098E 01 | 0.36942E 01 |
| 0.35977E 01 | 0.34942E 01 | 0.34041E 01 | 0.33210E 01 | 0.32582E 01 |
| 0.32285E 01 | 0.32158E 01 | 0.32129E 01 | 0.32108E 01 | 0.32115E 01 |
| 0.32105E 01 | 0.32116E 01 | 0.32119E 01 | 0.32136E 01 | 0.32136E 01 |

I = 28

| | | | | |
|---|---|---|---|---|
| 0.79875E 00 | 0.79750E 00 | 0.79518E 00 | 0.79349E 00 | 0.79289E 00 |
| 0.78870E 00 | 0.77800E 00 | 0.75658E 00 | 0.72724E 00 | 0.70320E 00 |

```
 0.68347E 00   0.66251E 00   0.64465E 00   0.62765E 00   0.61566E 00
 0.60869E 00   0.60629E 00   0.60494E 00   0.60500E 00   0.60457E 00
 0.60489E 00   0.60448E 00   0.60433E 00   0.60293E 00   0.60293E 00
I = 31
 0.50161E 00   0.50144E 00   0.50115E 00   0.50055E 00   0.49915E-00
 0.49591E-00   0.48878E-00   0.47563E-00   0.45765E-00   0.44301E-00
 0.43165E-00   0.41860E-00   0.40805E-00   0.39739E-00   0.39018E-00
 0.38586E-00   0.38468E-00   0.38375E-00   0.38398E-00   0.38355E-00
 0.38391E-00   0.38349E-00   0.38375E-00   0.38304E-00   0.38304E-00
I = 34
 0.42891E-00   0.42898E-00   0.42896E-00   0.42876E-00   0.42801E-00
 0.42583E-00   0.42042E-00   0.40936E-00   0.39324E-00   0.38093E-00
 0.37130E-00   0.36064E-00   0.35150E-00   0.34271E-00   0.33634E-00
 0.33295E-00   0.33175E-00   0.33121E-00   0.33118E-00   0.33105E-00
 0.33114E-00   0.33104E-00   0.33109E-00   0.33092E-00   0.33092E-00
I = 37
 0.66464E-01   0.66455E-01   0.66422E-01   0.66345E-01   0.66166E-01
 0.65720E-01   0.64719E-01   0.62880E-01   0.60417E-01   0.58357E-01
 0.56573E-01   0.54687E-01   0.52798E-01   0.51404E-01   0.50464E-01
 0.49802E-01   0.49643E-01   0.49463E-01   0.49523E-01   0.49428E-01
 0.49515E-01   0.49427E-01   0.49484E-01   0.49357E-01   0.49357E-01
I = 40
 0.20755E-02   0.20843E-02   0.20874E-02   0.20853E-02   0.20775E-02
 0.20591E-02   0.20233E-02   0.19663E-02   0.18958E-02   0.18281E-02
 0.17631E-02   0.16925E-02   0.16169E-02   0.15350E-02   0.14389E-02
 0.13271E-02   0.13732E-02   0.13084E-02   0.13674E-02   0.13066E-02
 0.13655E-02   0.12997E-02   0.13385E-02   0.12247E-02   0.12247E-02
I = 43
 0.36716E-04   0.36668E-04   0.36591E-04   0.36465E-04   0.36245E-04
 0.35840E-04   0.35160E-04   0.34184E-04   0.33016E-04   0.31806E-04
 0.30563E-04   0.29204E-04   0.27668E-04   0.25865E-04   0.23772E-04
 0.21624E-04   0.19769E-04   0.17291E-04   0.17312E-04   0.14742E-04
 0.17163E-04   0.14458E-04   0.16177E-04   0.12024E-04   0.12024E-04
I = 46
 0.46329E-06   0.46646E-06   0.46741E-06   0.46634E-06   0.46342E-06
 0.45794E-06   0.44918E-06   0.43710E-06   0.42265E-06   0.40691E-06
 0.38994E-06   0.37092E-06   0.34888E-06   0.32288E-06   0.29344E-06
 0.26270E-06   0.23310E-06   0.20434E-06   0.18206E-06   0.15386E-06
 0.14679E-06   0.10272E-06   0.12604E-06   0.75264E-07   0.75264E-07
I = 49
 0.26242E-07   0.26572E-07   0.26712E-07   0.26680E-07   0.26518E-07
 0.26203E-07   0.25704E-07   0.25026E-07   0.24208E-07   0.23294E-07
 0.22283E-07   0.21132E-07   0.19790E-07   0.18221E-07   0.16461E-07
 0.14626E-07   0.12841E-07   0.11166E-07   0.97188E-08   0.83054E-08
 0.73123E-08   0.57962E-08   0.52708E-08   0.27290E-08   0.
```

RUN G 4

TIME = 0.0028900 R = 0.92437E-01

I = 1

| | | | | |
|---|---|---|---|---|
| 0.11769E-05 | 0.11192E-05 | 0.10691E-05 | 0.10186E-05 | 0.96084E-06 |
| 0.89472E-06 | 0.82152E-06 | 0.74352E-06 | 0.66340E-06 | 0.58383E-06 |
| 0.50722E-06 | 0.43553E-06 | 0.37014E-06 | 0.31184E-06 | 0.26090E-06 |
| 0.21716E-06 | 0.18019E-06 | 0.14947E-06 | 0.12438E-06 | 0.10483E-06 |
| 0.89641E-07 | 0.81537E-07 | 0.73029E-07 | 0.84173E-07 | 0. |

I = 4

| | | | | |
|---|---|---|---|---|
| 0.50623E-05 | 0.48912E-05 | 0.47245E-05 | 0.45345E-05 | 0.43025E-05 |
| 0.40289E-05 | 0.37209E-05 | 0.33890E-05 | 0.30447E-05 | 0.26999E-05 |
| 0.23651E-05 | 0.20489E-05 | 0.17579E-05 | 0.14958E-05 | 0.12644E-05 |
| 0.10635E-05 | 0.89145E-06 | 0.74732E-06 | 0.62469E-06 | 0.53695E-06 |
| 0.43985E-06 | 0.45465E-06 | 0.40320E-06 | 0.62217E-06 | 0.62217E-06 |

I = 7

| | | | | |
|---|---|---|---|---|
| 0.56059E-04 | 0.56179E-04 | 0.55478E-04 | 0.53867E-04 | 0.51550E-04 |
| 0.48656E-04 | 0.45306E-04 | 0.41630E-04 | 0.37764E-04 | 0.33844E-04 |
| 0.29991E-04 | 0.26309E-04 | 0.22877E-04 | 0.19743E-04 | 0.16933E-04 |
| 0.14477E-04 | 0.12218E-04 | 0.10720E-04 | 0.80491E-05 | 0.98333E-05 |
| 0.82571E-05 | 0.10701E-04 | 0.96980E-05 | 0.13367E-04 | 0.13367E-04 |

I = 10

| | | | | |
|---|---|---|---|---|
| 0.64285E-03 | 0.62797E-03 | 0.61192E-03 | 0.59225E-03 | 0.56753E-03 |
| 0.53780E-03 | 0.50377E-03 | 0.46645E-03 | 0.42707E-03 | 0.38685E-03 |
| 0.34698E-03 | 0.30846E-03 | 0.27206E-03 | 0.23897E-03 | 0.20512E-03 |
| 0.19050E-03 | 0.16726E-03 | 0.19054E-03 | 0.16690E-03 | 0.19241E-03 |
| 0.17229E-03 | 0.20490E-03 | 0.19289E-03 | 0.23802E-03 | 0.23802E-03 |

I = 13

| | | | | |
|---|---|---|---|---|
| 0.58879E-02 | 0.58852E-02 | 0.58230E-02 | 0.56929E-02 | 0.55064E-02 |
| 0.52709E-02 | 0.49940E-02 | 0.46845E-02 | 0.43523E-02 | 0.40074E-02 |
| 0.36596E-02 | 0.33312E-02 | 0.29047E-02 | 0.30517E-02 | 0.28068E-02 |
| 0.29829E-02 | 0.27581E-02 | 0.29500E-02 | 0.27462E-02 | 0.29668E-02 |
| 0.28029E-02 | 0.30844E-02 | 0.29953E-02 | 0.33592E-02 | 0.33592E-02 |

I = 16

| | | | | |
|---|---|---|---|---|
| 0.51434E-01 | 0.50821E-01 | 0.50077E-01 | 0.49084E-01 | 0.47779E-01 |
| 0.46153E-01 | 0.44230E-01 | 0.42053E-01 | 0.39677E-01 | 0.37564E-01 |
| 0.36042E-01 | 0.36481E-01 | 0.34899E-01 | 0.35429E-01 | 0.34012E-01 |
| 0.34719E-01 | 0.33497E-01 | 0.34384E-01 | 0.33350E-01 | 0.34447E-01 |
| 0.33676E-01 | 0.35097E-01 | 0.34725E-01 | 0.36491E-01 | 0.36491E-01 |

I = 19

| | | | | |
|---|---|---|---|---|
| 0.37176E-00 | 0.37126E-00 | 0.36907E-00 | 0.36479E-00 | 0.35853E-00 |
| 0.35016E-00 | 0.33952E-00 | 0.33780E-00 | 0.33014E-00 | 0.32737E-00 |
| 0.31929E-00 | 0.31680E-00 | 0.30948E-00 | 0.30818E-00 | 0.30236E-00 |
| 0.30274E-00 | 0.29854E-00 | 0.30032E-00 | 0.29730E-00 | 0.30011E-00 |
| 0.29811E-00 | 0.30195E-00 | 0.30112E-00 | 0.30593E-00 | 0.30593E-00 |

I = 22

| | | | | |
|---|---|---|---|---|
| 0.22555E 01 | 0.22484E 01 | 0.22387E 01 | 0.22234E 01 | 0.22181E 01 |
| 0.22105E 01 | 0.21889E 01 | 0.21641E 01 | 0.21285E 01 | 0.20981E 01 |
| 0.20637E 01 | 0.20369E 01 | 0.20075E 01 | 0.19878E 01 | 0.19675E 01 |
| 0.19585E 01 | 0.19483E 01 | 0.19472E 01 | 0.19424E 01 | 0.19447E 01 |
| 0.19423E 01 | 0.19464E 01 | 0.19453E 01 | 0.19506E 01 | 0.19506E 01 |

I = 25

| | | | | |
|---|---|---|---|---|
| 0.60548E 01 | 0.60728E 01 | 0.60838E 01 | 0.60871E 01 | 0.60794E 01 |
| 0.60588E 01 | 0.60201E 01 | 0.59626E 01 | 0.58917E 01 | 0.58239E 01 |
| 0.57607E 01 | 0.57010E 01 | 0.56473E 01 | 0.56016E 01 | 0.55662E 01 |
| 0.55435E 01 | 0.55300E 01 | 0.55232E 01 | 0.55195E 01 | 0.55181E 01 |
| 0.55172E 01 | 0.55174E 01 | 0.55174E 01 | 0.55182E 01 | 0.55182E 01 |

I = 28

| | | | | |
|---|---|---|---|---|
| 0.21137E 01 | 0.21121E 01 | 0.21054E 01 | 0.20934E 01 | 0.20952E 01 |
| 0.20856E 01 | 0.20722E 01 | 0.20470E 01 | 0.20211E 01 | 0.19902E 01 |

| | | | | |
|---|---|---|---|---|
| 0.19650E 01 | 0.19367E 01 | 0.19158E 01 | 0.18936E 01 | 0.18805E 01 |
| 0.18675E 01 | 0.18632E 01 | 0.18570E 01 | 0.18572E 01 | 0.18535E 01 |
| 0.18547E 01 | 0.18510E 01 | 0.18517E 01 | 0.18473E 01 | 0.18473E 01 |
| I = 31 | | | | |
| 0.11611E 01 | 0.11576E 01 | 0.11533E 01 | 0.11471E 01 | 0.11383E 01 |
| 0.11260E 01 | 0.11097E 01 | 0.10985E 01 | 0.10882E 01 | 0.10734E 01 |
| 0.10630E 01 | 0.10490E 01 | 0.10402E 01 | 0.10287E 01 | 0.10234E 01 |
| 0.10162E 01 | 0.10152E 01 | 0.10113E 01 | 0.10123E 01 | 0.10094E 01 |
| 0.10107E 01 | 0.10076E 01 | 0.10082E 01 | 0.10042E 01 | 0.10042E 01 |
| I = 34 | | | | |
| 0.82654E 00 | 0.82678E 00 | 0.82598E 00 | 0.82384E 00 | 0.82017E 00 |
| 0.81452E 00 | 0.80633E 00 | 0.79535E 00 | 0.78228E 00 | 0.76866E 00 |
| 0.76234E 00 | 0.75380E 00 | 0.74829E 00 | 0.74113E 00 | 0.73775E 00 |
| 0.73338E 00 | 0.73273E 00 | 0.73042E 00 | 0.73105E 00 | 0.72939E 00 |
| 0.73020E 00 | 0.72841E 00 | 0.72885E 00 | 0.72659E 00 | 0.72659E 00 |
| I = 37 | | | | |
| 0.22789E-00 | 0.22731E-00 | 0.22666E-00 | 0.22578E-00 | 0.22446E-00 |
| 0.22254E-00 | 0.21986E-00 | 0.21637E-00 | 0.21227E-00 | 0.20791E-00 |
| 0.20344E-00 | 0.19886E-00 | 0.19445E-00 | 0.19204E-00 | 0.19145E-00 |
| 0.18967E-00 | 0.18983E-00 | 0.18866E-00 | 0.18920E-00 | 0.18821E-00 |
| 0.18874E-00 | 0.18760E-00 | 0.18787E-00 | 0.18642E-00 | 0.18642E-00 |
| I = 40 | | | | |
| 0.35814E-01 | 0.35893E-01 | 0.35865E-01 | 0.35719E-01 | 0.35463E-01 |
| 0.35089E-01 | 0.34586E-01 | 0.33956E-01 | 0.33217E-01 | 0.32395E-01 |
| 0.31509E-01 | 0.30574E-01 | 0.29605E-01 | 0.28620E-01 | 0.27633E-01 |
| 0.26543E-01 | 0.26786E-01 | 0.26341E-01 | 0.26666E-01 | 0.26222E-01 |
| 0.26494E-01 | 0.25947E-01 | 0.26081E-01 | 0.25359E-01 | 0.25359E-01 |
| I = 43 | | | | |
| 0.49096E-02 | 0.48710E-02 | 0.48363E-02 | 0.47991E-02 | 0.47514E-02 |
| 0.46893E-02 | 0.46109E-02 | 0.45155E-02 | 0.44039E-02 | 0.42776E-02 |
| 0.41382E-02 | 0.39878E-02 | 0.38281E-02 | 0.36616E-02 | 0.34903E-02 |
| 0.33163E-02 | 0.31406E-02 | 0.29590E-02 | 0.28231E-02 | 0.27164E-02 |
| 0.28009E-02 | 0.26548E-02 | 0.26987E-02 | 0.25031E-02 | 0.25031E-02 |
| I = 46 | | | | |
| 0.56278E-03 | 0.56697E-03 | 0.56774E-03 | 0.56509E-03 | 0.55997E-03 |
| 0.55255E-03 | 0.54283E-03 | 0.53080E-03 | 0.51648E-03 | 0.49999E-03 |
| 0.48146E-03 | 0.46109E-03 | 0.43916E-03 | 0.41595E-03 | 0.39180E-03 |
| 0.36705E-03 | 0.34197E-03 | 0.31672E-03 | 0.29132E-03 | 0.26545E-03 |
| 0.24066E-03 | 0.20432E-03 | 0.21122E-03 | 0.18098E-03 | 0.18098E-03 |
| I = 49 | | | | |
| 0.16086E-03 | 0.16395E-03 | 0.16547E-03 | 0.16540E-03 | 0.16427E-03 |
| 0.16225E-03 | 0.15943E-03 | 0.15583E-03 | 0.15146E-03 | 0.14634E-03 |
| 0.14052E-03 | 0.13404E-03 | 0.12699E-03 | 0.11947E-03 | 0.11159E-03 |
| 0.10348E-03 | 0.95260E-04 | 0.87018E-04 | 0.78801E-04 | 0.70604E-04 |
| 0.62368E-04 | 0.53885E-04 | 0.45917E-04 | 0.34796E-04 | 0. |

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